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Integrated Operations in the Oil and Gas Industry:

Sustainability and Capability Development

Tom Rosendahl
BI Norwegian Business School, Norway

Vidar Hepsø
Norwegian University of Science and Technology (NTNU), Norway

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Preface

INTRODUCTION

The predicted "ICT revolution" has gained increasing attention in the oil industry the last few years. It is enabled by the use of ubiquitous real time data, collaborative techniques, and multiple expertise across disciplines, organizations and geographical locations. This has made it possible to develop heavily instrumented and automated oil fields that utilize people and technology to remotely monitor, model and control processes in a collaborative, safe and environmentally friendly way in order to maximize the value of field life. Since the turn of the millennium, most major oil companies and global operating vendor/service companies have increasingly addressed oil exploration and operation enabled by information and communication technology as their future way of doing business. Integrated Operations (IO) is a concept used to describe this new way of doing business. Similar is oil exploration, field development and operation enabled by emerging information and communication technologies.

The field of Integrated Operations and the knowledge associated with this development is increasingly created in the borderland between universities, companies, national legislative/governing bodies, and various global actors. In sum, "Integrated Operations" has become an arena where a multitude of actors meet, often with different agendas and objectives but seen as something that create substantial "efficiency" leaps for the oil industry globally.

The first attempts of designing Integrated Operations were performed by Superior Oil (Booth & Hebert 1989) which established drilling data centers, providing real-time log, and "measurement while drilling" data to shore based teams (Wahlen et al. 2002). These early attempts of improving the procedures for critical drilling projects established the path for the future development of IO within the industry. The idea was based on multidisciplinary teams sharing information in a simultaneous manner, using high-tech instruments to ensure a sufficient flow of information. This mode of operation was anticipated to increase the cooperation between different fields of expertise thus improving decision accuracy in addition to cutting costs.

In relation to the Norwegian oil industry, the first implementation of IO took place around the turn of the millennium. In 1997 Baker Hughes INTEQ (see also Chapter 13) started planning for a project, in cooperation with Norsk Hydro and BP, which was supposed to facilitate the relocation of people from offshore installations to an Operations Service Centre onshore. In 2000 the project launched with a centre capable of supporting five offshore rigs simultaneously (Wahlen et al. 2002). ConocoPhillips went in the same direction, and established an onshore drilling centre in Tananger in 1999 (Herbert, Pedersen & Pedersen 2003).

Norway has been important for the development of Integrated Operations. Since oil first was found and extracted on the Norwegian continental shelf (NCS) in the early 1970s, this industry has served as the main contributor to the rise of Norwegian economy and welfare. As companies in any other industry, the operators on the NCS compete for profits and competitive advantage. Much of the IO work processes, concepts, and new technologies are also developed and tested on the Norwegian continental shelf before it is deployed globally. Some related initiatives among suppliers and operators are referred to as Smart Operations (Petoro), Smart Fields (Shell), Field of the future (BP), Real Time Operations (Halliburton), Smart Wells (Schlumberger), and i-fields (Chevron) (Henriquez 2008 et al.).

Within the petroleum industry the term Integrated Operations basically refers to work processes that allow for a tighter integration of offshore and onshore personnel, as well as operator and service companies (Skarholt et al. 2009). This integration is made possible by modern information and communications technology (ICT), and high bandwidth fiber optic networks that allows real-time data sharing between remote locations (Gulbrandsøy et al. 2004). Experts from different disciplines can collaborate more closely, which facilitates for more rapid response and decision making (Rosendahl & Egir 2008).

Today most major oil companies have IO programs or have moved their operational model in the direction of IO but the the NCS is still regarded by many as the world's most advanced basin in terms of developing such initiatives (Henriquez et al. 2008). The new work processes of IO represent a parallel way of collaborating, which contrasts with the traditional sequential way of performing work (OLF 2005). Various professionals with multidisciplinary backgrounds are now able to analyze real-time data in collaboration, thus making decisions and taking corrective actions to optimize rig site production rapidly. In addition such collaborations are no longer dependent on one physical location because the new technology allows for the onshore assembling of people with the needed competencies (Rosendahl & Egir 2008; OLF 2005).

One of the key components related to IO is the establishment of onshore support centers which has enabled companies to move work tasks from offshore platforms to land. As employees are moved onshore, the need for virtual communication and collaboration between sea and land emerges. Virtuality can be defined as activities between parties that are in different geographical locations (Gulbrandsøy et al. 2004). Accordingly, a virtual organization consists of people working towards a shared goal across space, time, and organizational boundaries made possible by webs of communication technologies (Gulbrandsøy et al. 2004). The technological capabilities are realized in so-called *collaboration rooms*. Such rooms facilitate for cooperation by utilizing videoconferencing, sharing of large data sets, and remote control and monitoring (Hepsø 2009; Henriquez et al. 2008; Rosendahl & Egir 2008; Herbert, Pedersen & Pedersen 2003; Ursem et al. 2003). These rooms contain large screens for sharing of data and possibilities for real-time data transmission between land and sea, vendors and suppliers, and other departments deemed important.

Why Implement IO?

In general the rationale behind implementing IO is based on the belief that this way of organizing work will streamline operations and increase effectiveness, thus leading to a competitive advantage and increased profits (OLF 2005). Based on the definition of IO which was presented earlier, it is anticipated that the organization by integrating its operations will improve its decisions, both with respect to time and accuracy. Further, the fact that technology provides the opportunity to control offshore processes and equipment from onshore locations implies more effective operations. The ability to assemble important

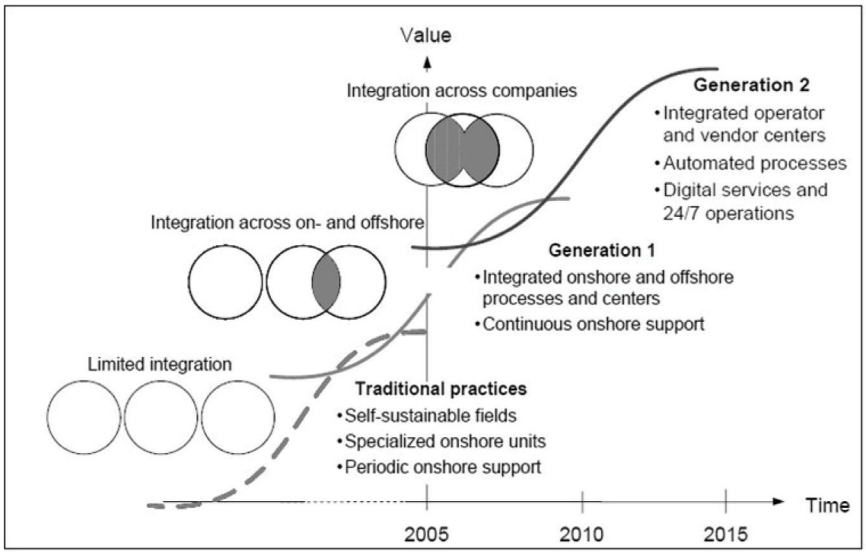
functions on an onshore location will also include a reduced need for offshore personnel. Already in 2003, a study by OLF on a drilling pilot project found that on some platforms, a reduction of up to 70 percent in personnel had been carried out without reduction in security.

In addition to the positive implications for effectiveness, implementation of IO is expected to have beneficial effects on Health, Safety and Environmental issues (HSE) in the industry (OLF 2007). Greater continuity and integration of activities will enhance the integration of management offshore and onshore, and potentially improve HSE issues. Offshore management can focus more of its attention on operational issues and less on administrative tasks, while performing the planning and work preparation onshore will increase the long-term focus on each asset, increase safety, and reduce the risk of environmental hazards (Grøtan & Albrechtsen 2008; Henriquez et al 2008; Ringstad & Andersen 2006).

In a report from 2007 the OLF estimated that if the oil and gas companies in the Norwegian shelf were to quickly integrate their operations, revenues from the shelf could be increased by approximately 300 Billion NOK (OLF 2007). This is around 50 Billion USD. Such an estimate provides a good incentive for companies within the industry to rapidly implement IO in their organizations. It also displays some of the belief that IO represents the future for the oil industry, and that the companies who first adapt to this operational mode will gain an advantage. It was foreseen that IO would be implemented over three generations (OLF 2005) with increasing integration; across geography, across disciplines and across organizational borders (Figure 1).

According to OLF (2005) the first generation (G1) processes will integrate processes and people onshore and offshore using ICT solutions and facilities that improve onshore's ability to support offshore operationally. The second generation (G2) processes will help operators utilize vendors' core competencies and service more efficiently. Utilizing digital services and vendor products, operators will be able to update reservoir models, drilling targets, and well trajectories as wells are drilled; manage well completions remotely; and optimize production from reservoir to export.

Figure 1. Existing and future practices (OLF, 2005)



Issues in Implementing IO

IO as a concept tap into technological issues in the oil industry, as well as issues related to the organization, its people, and its work processes (Rosendahl & Egir 2008; Ringstad & Andersen 2006; Herbert, Pedersen & Pedersen 2003; Ursem et al. 2003). To capture these different aspects of the organization, literature has proposed the concept of Man-Technology-Organization (MTO) (Andersson & Rollenhagen 2002). If IO-related work processes are to be successfully implemented it will require considering all three aspects of this system perspective. Although it appears in retrospect that the implementation of IO on the NCS has been relatively successful, severe challenges were faced regarding the development of new work practices and the management of change – the combined integration of people, processes, and technology (Rosendahl & Egir 2008; Hepsø 2006; Ringstad & Andersen 2006). Over the last ten years Integrated Operations have gone from initiatives started by enthusiasts, through pilot testing and broad implementation of new IO practices. Some efforts of implementation of IO have been scalable and sustainable; others have never been able to pass the general adoption threshold or chasm (Hepsø. et al. 2010) of piloting and good intentions.

According to Hepsø (2006) and Edwards, et al. (2010) there was an overoptimistic belief in IO at the turn of the millennium, as to how easy it would be to implement and gain results from it. The Norwegian Ministry of Petroleum and Energy (NOU 2003) defined IO almost ten years ago as: "Use of information technology to change work processes to achieve improved decisions, remote control of processes and equipment, and to relocate functions and personnel to a remote installation or an onshore facility." Much of the early work on IO was technology biased and was treating human and organizational issues as a remaining factor (Hepsø 2006). Remote control was heralded with great technological enthusiasm. Ten years after we see that remote control has not proven to be as important as promised. On the other side, it was also heralded that Integrated Operations was all about people and processes and nothing about technology. In a sense both technology and social determinist views on IO were wrong. The implementation of IO involves the restructuring of work processes and the management of employees, which are undoubtedly two of the cornerstones of change. Different factors can drive the change forwards, while at the same time, other factors may hinder the change. As a consequence, being able to successfully manage change is of the utmost importance.

A CAPABILITY PERSPECTIVE

In this anthology we are interested in a capability approach to Integrated Operations that documents research and development in the oil industry. A capability perspective is a natural continuation of an IO change perspective that started with a man, technology and organization (MTO) perspective already presented (Andersson & Rollenhagen 2002, Ringstad & Andersen 2006, Grøtan & Albrechtsen 2008). By a capability we mean the combined capacity and ability to plan and execute in accordance with business objectives through a designed combination of human skills, work processes, governance and technology.

The capability perspective addresses the human, process, governance and technology issues of Integrated Operations through a holistic approach (Edwards et.al 2010). It can be used to understand how firms engage in networked relationships to impact learning/performance and develop distinctive practices rather than focusing only on technology. Given that the organization exists in a networked setting with heterogeneous resources, the challenge is how to configure the firm's resources into scalable and sustainable capabilities that achieve desired actions and outcomes.

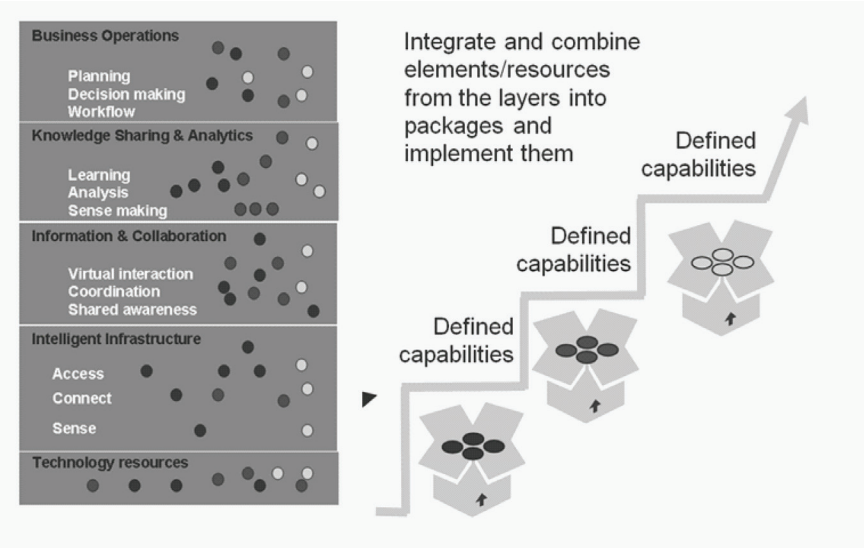
- **Technology:** Buildings working environments, facilities, plants, pipelines, equipment and systems, automation, IT and communication, software, and data_
- **Process:** Business processes - workflow, roles and responsibilities, and collaboration
- **People:** Skills, competence, experience, leadership, and all other soft people issues
- **Governance:** Organization, positions (decision rights), location of resources, business structure, internal/external sourcing, contracts, agreements, rules, and regulations

Henderson et.al in Chapter 1 in this anthology define the key elements of a capability approach in Integrated Operations for oil and gas application. Capability development is placed in an ecosystem/ ecology framework. Henderson et al. argue that there are a number of layers or niches that can be used to provide a strategic view of the ecology of Integrated Operations. All IO development work is about creating and sustaining different configurations of these layers:

- Technology resource layer
- An intelligent infrastructure
- Information and collaboration layer
- Knowledge sharing and analytics layer
- A business operations layer

A stepwise approach of capability development means that for each step in the development process a unique configuration of the four capability elements must be set up; people, process, governance, and technology. Scalability and sustainability will result when the layers are configured with the proper combinations of the four capability elements, see Figure 2.

Figure 2. The proper combinations of the capability elements



A PRESENTATION OF THE CHAPTERS IN THE ANTHOLOGY

The anthology is a collection of ongoing work with IO and many of the authors have worked with IO for many years, some of them experts both in research and deployment of IO in the oil and gas business. The geographical distribution of the authors signals that IO is a global phenomenon; Norway, Denmark, Great Britain, Austria, USA, Brazil and Holland. The authors are oil company employees, from oil and gas vendors, consultants, researchers or university faculty members. The different chapters in this anthology share to large degree the content of these IO definitions presented in the introduction, even though there is some variety in the understanding and use of IO in the chapters. The contributors of the anthology has to a larger or lesser sense focused on various parts of the capability stack. Not all the chapters are using the capability language explicitly but all authors stress the need to have a holistic perspective on Integrated Operations.

In the first section, *Introduction and Definitions*, after the introduction by Rosendahl and Hepsø that you are currently reading, we start with an introduction to the key concepts in the anthology. This is given by Henderson, Hepsø, and Mydland in their chapter *What is a Capability Platform Approach to Integrated Operations? An Introduction to Key Concepts*. They argue that the capability language allows us to unpack the role of technology by emphasizing its interaction with people, process and governance issues. Further, they address the importance of a capability approach for Integrated Operations and how it can improve our understanding of how people, process, technology and governance issues are connected and managed to create scalable and sustainable practices. Also, the authors describe the development of capabilities as something that is happening within an ecology.

Section 2, *People, Process, Governance, and Technology Capabilities*, consists of eight chapters. Skarholt, Hansson, and Lamvik show *'How Integrated Operations Has Influenced Offshore Leadership Practice'* in their chapter. They discuss how IO has affected new ways of working, and address leadership practice in particular. Also, they investigate both the positive and negative effects of IO in terms of virtual leadership teams and local leadership offshore, and how this may affect safety on board. The chapter *'Creating an IO Capable Organization - Mapping the Mindset'* by Madsen, Hansson, and Danielsen, starts by claiming that IO is an organizational change process where the mindset of the organization and the mindset of individuals affects this change process and vice versa. In the chapter the authors discuss the changes introduced by IO, requirements to the change management process, and a concept called IO Mindset.

In his chapter, *Collaborative Work Environments in Smart Oil Fields: The Organization Matters!*, Guldemond claims that in the last decade, oil companies are increasingly viewing Collaborative Work Environments as an important component of their Smart Oil Fields programs. Collaborative Work Environments (CWEs) have been implemented by several major oil companies, to support the use of technology in Smart Oil Fields. The implementation of these Collaborative Work Environments is not without problems. After major oil companies successfully implemented the hardware, tools and applications in CWEs, organizational design challenges remained unsolved. The biggest challenge is to change behavior of staff and to effectively integrate people across disciplinary boundaries, he states.

Chapter 5, *Connecting Worlds through Self-Synchronization and Boundary Spanning: Crossing Boundaries in Virtual Teams*, by Filstad, Hepsø, and Skarholt, investigates knowledge sharing in collaborative work. Through two empirical studies of personnel working offshore and onshore in an oil company, they address the role of self-synchronization and boundary spanning as practices for improving collaboration in Integrated Operations. The authors focus on the following enabling capabilities for collaborative work: management, knowledge sharing, trust, shared situational awareness, transparency,

information and communication technology. In the next chapter, *Teams: The Intersection of People and Organisational Structures in Integrated Operations*, Taylor describes the success and sustainability of the IO initiative within the oil and gas industry. IO is discussed in relation to the ways people work together and the organizational structures which support that work. Whilst collaboration has become a defining concept in the industry for optimal working, this chapter argues that other characteristics found in the concept of teamwork are of equal importance in achieving the aims of the IO project.

In his chapter, *Managing Team Leadership Challenges in Integrated Operations*, Larsen gives an empirically based account of leadership of teamwork in Integrated Operations settings, or "IO teamwork" as it is termed here. First, a brief presentation of the characteristics of IO teamwork and its leadership is provided. Then follows an overview of relevant theoretical perspectives to the study of team leadership in IO settings. Next, central challenges regarding leadership of IO teamwork are discussed, and empirical examples of how leaders of IO teams go about managing these challenges are provided. Elke, in Chapter 8, *Implementing iE – Learnings from a Drilling Contractor*, argues that utilization of iE has been regarded as a vital measure for avoiding a rapid decline in production. Implementation has however proven to be challenging, and an un-harvested potential still exist. Taking a capability approach to such implementation may help us attain this remaining potential. Doing so requires us to have a good understanding of what factors that secures a successful and sustainable iE-implementation. Here, a case study of how a drilling contractor has adopted iE is used as basis for identifying such factors.

Chapter 9, the last in this section, is entitled *Good IO-Design is More than IO-Rooms*, written by Moltu. She argues that IO is about employing real time data and new technology to remove barriers between disciplines, expert groups, geography, and the company. IO has been associated with so called IO rooms. IO is technology driven, but is neither room nor technology deterministic. A network understanding of IO, based on Science and Technology Studies, gives a process of different *actants* chained in networks, pointing the same directions by the same interests, to obtain the anticipated effect as is comes to efficiency and good HSE results. This chapter develops the seamless web of the IO design and describes good design criteria based on studies in Operational Support Rooms.

Section 3, *Planning, Concurrent Design, and Team*, starts with a chapter by Rosendahl, Egir, and Rolland, titled *How to Implement Multi Disciplinary Work Processes in the Oil Industry: A Statoil Case.* They explore possibilities for using Concurrent Design at Statoil, seeking to understand how they should proceed in implementing this kind of work, and consider potential pitfalls of using this method. The authors offer ideas that can minimize the time required to implement the multi-disciplinary approach of Concurrent Design. Chapter 11, *Implementing Integrated Planning: Organizational Enablers and Capabilities*, by Ramstad, Halvorsen, and Holte, focuses on how transferring the IO principles to the planning domain has led to the development of the concept of Integrated Planning. The concept represents a holistic perspective on planning, emphasizing the interplay between planning horizons, between organizational units, and among cross-organizational partners. Based on findings from three case studies, the purpose of this chapter is to present how three companies in the oil and gas industry has approached integrated planning, illustrating some of the challenges they have experienced in the planning domain. Skjerve, Rindahl, Sarshar, and Braseth complete Section 3 with their chapter *Promoting Onshore Planners' Ability to Address Offshore Safety Hazards*. Here is a development of a new generation of Integrated Operations, where the number of offshore staff may be reduced and more tasks allocated to onshore staff. As a consequence, onshore planners may increasingly be required to address safety hazards when planning for task performance offshore. The chapter addresses the question of how onshore planners' ability to address offshore safety hazards during planning of maintenance and modification tasks can be promoted by use of visualization technology.

Also Section 4, *Cases*, consists of three chapters. First Fraser, Dagestad, and Jones introduce *Baker Hughes IO & BEACON with a Focus on Downsizing Personnel Requirements at Rig-Site*. The authors describe how Baker Hughes, an IO pioneer, for more than a decade has developed a number of IO applications and WellLink technologies building its BEACON (Baker Expert Advisory Centre Operation Network) platform for the digital oilfield. The scope of BEACON is remote access of real-time rig data, drilling data and wire line data, production and pump monitoring and static file management. These technologies have enabled the company's collaboration centers around the world primarily to monitor, support and optimize operations without having to be physically present at rig site. In chapter 14, *Integrated Operations in Petrobras: A Bridge to Pre-Salt Achievements,* Lima and Adilson describes Petrobas as an integrated energy company that operates in all segments of the oil industry. The company has a broad management experience and uses a multidisciplinary approach, which applies to different areas. Recently, the impressive discoveries of the Pre-Salt reserves have created an exciting scenario in multiple aspects. Petrobras expects to produce by 2020 more than 5 million bpd of oil, out of which 1 million only from Pre-Salt. This leads to an approach that will require scalable and sustainable solutions that take into account the better understanding of how people, processes, technology, and governance issues are connected and managed. The last chapter in this section, *The Introduction of a Hand-Held Platform in an Engineering and Fabrication Company*, by Lorentzen Hepsø, Waldal, and Rindal, focuses on the organization Fabricom, and seeks to uncover which capabilities lies within the hand-held devices, and which effects the implementation of such devices could have on Fabricom's work processes. Through an abductive approach, based on observations, semi-structured interviews, and document analysis, the authors focus on the workflow and communication practices in Fabricom.

Section 5, *Leadership and Learning*, starts with chapter 16, *Adaptive Advisory Systems for Oil and Gas Operations*, by Al-Kinani, Cakir, Baumgartner, and Stundner. This chapter describes a framework that captures knowledge in an organization and applies it in daily operations. Knowledge capturing is one of the biggest upcoming challenges to oil and gas organizations as operations become more remote, more challenging and many experts are leaving the oil and gas industry. A methodology is described to capture the knowledge of experts centrally and apply it throughout all operations in the organization. The next chapter describes *Integrated Operations from a Change Management Perspective*. The authors, Rosendahl, Egir, Due Sørensen, and Ulsund, are focusing on trends in implementing Integrated Operations across companies. Findings are presented in a modified version of Kurt Lewin's Force Field Analysis. They found multiple forces that have affected the implementation of Integrated Operations to various extents, and this chapter focuses on three of them: understanding the rationale of IO, establishing support for change, and technological solutions.

In chapter 18, *Knowledge Markets and Collective Learning: Designing Hybrid Arenas for Learning Oriented Collaboration*, Bremdal and Korsvold argue that "Knowledge Markets" might be used as a term to describe how individuals can be engaged in a democratic process where their competence, background and personal information resources are mobilized in full in a broad and non-biased process. The contribution of each individual is aggregated and averaged in a way that the authors believe will yield more accurate results, personal involvement and learning than traditional approaches to group efforts. *The Terms of Interaction and Concurrent Learning in the Definition of Integrated Operations,* by Steiro and Torgersen, completes this section of the book. This chapter introduces a new definition of IO adapted to the oil industry. This definition focuses on interaction. Such an approach, we believe is necessary to emphasize learning processes in the organization's various echelons. It is an important assumption for the success of IO as a flexible and complex organization. The term "Interaction" is elaborated with special emphasis on "Concurrent Learning."

The last section, *Resilience & HSE*, starts with chapter 20, *IO, Co-agency, Intractability, and Resilience*. The author, Hollnagel, claims that technological developments continuously create opportunities that are eagerly adopted by industries with a seemingly insatiable need for innovation. This has established a forceful circulus vitiosus that have resulted in exceedingly complicated socio-technical systems. The introduction of Integrated Operations in drilling and off-shore operations is one, but not the only, example of that. This development poses a challenge for how to deal with risk and safety issues. Where existing safety assessment methods focus on descriptions of component capabilities, complicated socio-technical systems must be described in terms of relations or even functional couplings. In order to design, analyze, and manage such systems, we must acknowledge that performance adjustments are a resource rather than a threat. Safety can no longer be achieved just by preventing that something goes wrong, but must instead try to ensure that everything goes right.

In chapter 21, the authors Albrechtsen and Weltzien discuss *IO Concepts as Contributing Factors to Major Accidents and Enablers for Resilience-Based Major Accident Prevention*. On the one side inadequacy of IO-concepts can, in combination with other factors, contribute to major accidents. On the other side, work processes and technology within an IO-context contribute to prevent major accidents. This chapter shows how IO concepts can enable a resilience-based approach to major accident prevention by employing a case study of an onshore drilling center. Interviews indicate that drilling and well operations justify a resilience approach, as these operations are complex and dynamic. Finally, in chapter 22, *Introducing IO in a Drilling Company: Towards a Resilient Organization and Informed Decision-Making?,* the authors Osborg Ose and Steiro shows that the introduction of Integrated Operations in the offshore oil and gas industry makes distanced and distributed decision-making a growing part of normal work. Some functions have been transferred from offshore installations to onshore offices as a consequence of the technologies that have recently become available. They analyze whether the onshore organization is ready for increased responsibilities by increasing the resilience in its work patterns, since resilience is important for maintaining or increasing safety level compared to current operation, where personnel on board installations can observe the plant at first hand.

Tom Rosendahl
BI Norwegian Business School, Norway

Vidar Hepsø
Norwegian University of Science and Technology, Norway

REFERENCES

Andersson, O., & Rollenhagen, C. (2002). *The MTO concept and organizational learning at Forsmark NPP, Sweden.* Presentation held at the IAEA International Conference on Safety Culture in Nuclear Installations, Rio de Janeiro, Brazil, 2-6 December.

Booth, J. E., & Hebert, J. W., II. (1989). *Support of drilling operations using a central computer and communications facility with real-time MWD capability and networked personal computers*. Petroleum Computer Conference, 26-28 June, San Antonio, Texas.

Edwards, T., Mydland, Ø., & Henriquez, A. (2010). *The art of intelligent energy (iE)- Insights and lessons learnt from the application of iE.* SPE-paper 128669, Presented at Intelligent Energy Conference in Utrecht, February.

Grøtan, T. O., & Albrechtsen, E. (2008). *Risikokartlegging og analyse av Integrerte Operasjoner (IO) med fokus på å synliggjøre kritiske MTO-aspekter – SINTEF rapport*.

Gulbrandsøy, K., Andersen, T. M., Hepsø, V., & Sjong, D. (2004). *Integrated operations and e-fields in maintenance and operation: the third efficiency leap facing the Norwegian oil and gas industry*. Paper presented at the MARCONI Conference.

Henriquez, A., Fjærtoft, I., Yttredal, O., & Johnsen, C. (2008). *Enablers for the successful implementation of intelligent energy: The Statoil case*. Intelligent Energy Conference and Exhibition, 25-27 February 2008, Amsterdam, The Netherlands.

Hepsø, V. (2006). *When are we going to address organizational robustness and collaboration as something other than a residual factor?* SPE Intelligent Energy Conference and Exhibition, 11-13 April, 2006, Amsterdam, The Netherlands.

Hepsø, V. (2009). Common information spaces in knowledge-intensive work: Representation and negotiation of meaning in computer-supported collaboration rooms . In Jemielniak, D., & Kociatkiewicz, J. (Eds.), *Handbook of research on knowledge-intensive organizations* (pp. 279–294). Hershey, PA: IGI Global. doi:10.4018/978-1-60566-176-6.ch017

Hepsø, V., Olsen, H., Joannette, F., & Brych, F. (2010). *Next-steps to a framework for global collaboration to drive business performance.* SPE-paper 126207. Intelligent Energy Conference in Utrecht, February.

Herbert, M., Pedersen, J., & Pedersen, T. (2003). *A step change in collaborative decision making – Onshore drilling center as the new work space.* SPE Annual Technical Conference and Exhibition, 5-8 Oct, Colorado, US.

NOU. (2003). *NOU official Norwegian report to the Storting nr 38 On the Petroleums business*. Retrieved from http://odin.dep.no/filarkiv/209387/STM0304038-TS.pdf

OLF. (Norwegian Oil Industry Association). (2007). HMS og Integrerte operasjoner: Forbedringsmuligheter og nødvendige tiltak. Retrieved August 19, 2011, from http://www.ptil.no/getfile.php/PDF/IO%20og%20HMS-%20OLF-rapport.pdf

OLF (Norwegian Oil Industry Association). (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf*. Retrieved September 21, 2009, from http://www.olf.no/getfile.php/zKonvertert/www.olf.no/Rapporter/Dokumenter/051101%20Integrerte%20arbeidsprosesser,%20rapport.pdf

Ringstad, A. J., & Andersen, K. (2006). *Integrated operations and HSE – Major issues and strategies*. SPE International Conference on Healt, Safety and Environment in Oil and Gas Exploration and Production, 2- 4 April, Abu Dhabi, UAE.

Rosendahl, T., & Egir, A. (2008). Multidisiplinære team og oljeindustrien – Hvordan implementere Concurrent Design i StatoilHydro? *Magma (New York, N.Y.)*, *(n.d)*, 6.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. S. (2009). Empowering operations and maintenance: Safe operations with the 'one directed team' organizational model at the Kristin asset . In Martorell, S., Soares, C. G., & Bennett, J. (Eds.), *Safety reliability and risk analysis: Theory, methods and applications* (pp. 1407–1414). London, UK: Taylor & Francis Group.

Ursem, L.-J., Williams, J. H., Pellerin, N. M., & Kaminski, D. H. (2003). *Real time operations centres; The people aspect of Drilling decision making*. SPE/IADC Drilling Conference, 19-21 Feb., Amsterdam, The Netherlands.

Wahlen, M., Sawaryn, S., Smith, R., & Blaasmo, M. (2002). *Improving team capability and efficiency by moving traditional rig-site services onshore*. European Petroleum Conference, 29-31 Oct. Aberdeen, Scotland.

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Detailed Table of Contents

Preface xvii

Acknowledgment xxviii

Section 1
Introduction and Definitions

Chapter 1
What is a Capability Platform Approach to Integrated Operations? An Introduction to Key Concepts 1
John Henderson, Boston University, USA
Vidar Hepsø, Norwegian University of Science and Technology (NTNU), Norway
Øyvind Mydland, Stepchange, Norway

The concept of a capability platform can be used to argue how firms engage networked relationships to embed learning/performance into distinctive practices rather than focusing only on technology. In fact the capability language allows us to unpack the role of technology by emphasizing its interaction with people, process, and governance issues. The authors address the importance of a capability approach for Integrated Operations and how it can improve understanding of how people, process, technology, and governance issues are connected and managed to create scalable and sustainable practices. The chapter describes the development of capabilities as something that is happening within an ecology. Using ecology as a metaphor acknowledges that there is a limit to how far it is possible to go to understand organizations and the development of capabilities in the oil and gas industry as traditional hierarchies and stable markets. The new challenge that has emerged with integrated operations is the need for virtual, increasingly global, and network based models of work. The authors couple the ecology approach with a capability platform approach.

Section 2
People, Process, Governance, and Technology Capabilities

Chapter 2
How Integrated Operations has Influenced Offshore Leadership Practice 21
Kari Skarholt, SINTEF, Norway
Lisbeth Hansson, SINTEF, Norway
Gunnar M. Lamvik, SINTEF, Norway

This chapter discusses how Integrated Operations (IO) has affected new ways of working and addresses leadership practice in particular. It investigates both the positive and negative effects of IO in terms of virtual leadership teams and local leadership offshore, and how this may affect safety on board. IO contributes to the onshore organization being more actively involved in problem-solving and decision-making in offshore operations compared to earlier. This way, it has become easier to reach a shared situational awareness concerning planning and prioritizing of operations on board. However, the authors find that the integration of sea and land has not been successful in achieving increased hands-on leadership offshore. To explore this issue, they discuss findings from different research projects studying IO and changes in work practices onshore and offshore at different installations/assets in a Norwegian oil and gas company.

Chapter 3

Creating an IO Capable Organization: Mapping the Mindset 40
Bjørn-Emil Madsen, SINTEF, Norway
Lisbeth Hansson, SINTEF, Norway
Jan Eivind Danielsen, Bouvet, Norway

Integrated Operations (IO) is an organizational change and the mindset of the organization and the mindset of individuals affects this change process and vice versa. In this chapter, the authors discuss the changes introduced by IO, requirements to the change management process and a concept, they call IO Mindset. Change processes may be supported by use of tools and methods such as surveys and interviews. The chapter describes three different methods especially developed to assist IO change management processes, all including IO Mindset elements. The first one, TAM-IO, supports implementation of new ICT tools while CCP supports the change towards team based work forms. The third method, IO Mindset assessment is a newly developed tool, taking into consideration experience gained through implementation of IO and experience with other tools. Pilot testing of IO mindset assessment is described and discussed. This work is based on the "IO Mindset project" performed in the "IO centre" (Madsen et. al, 2011).

Chapter 4

Collaborative Work Environments in Smart Oil Fields: The Organization Matters! 59
Ewoud Guldemond, Atos Consulting, The Netherlands

In the last decade, oil companies are increasingly viewing collaborative work environments as an important component of their smart oil fields programs. Collaborative work environments (CWEs) have been implemented by several major oil companies, to support the use of technology in smart oil fields. The implementation of these collaborative work environments is not without problems. After major oil companies successfully implemented the hardware, tools and applications in CWEs, organizational design challenges remained unsolved. The biggest challenge is to change behavior of staff and to effectively integrate people across disciplinary boundaries. This chapter emphasizes the importance of the organizational aspect of CWEs in smart oil fields. The objective of this chapter is to provide the upstream petroleum industry with guidelines for the organizational design of the collaborative work environments, in support of the operation of smart oil fields. In order to provide the organizational design guidelines, a PhD research was conducted at three different operating units of a major oil company. This research focused on the business processes, organizational structure, and competencies of staff in the CWEs.

Chapter 5
Connecting Worlds through Self-Synchronization and Boundary Spanning: Crossing Boundaries in Virtual Teams 76
Cathrine Filstad, BI Norwegian Business School, Norway
Vidar Hepsø, Norwegian University of Science and Technology (NTNU), Norway
Kari Skarholt, SINTEF, Norway

This chapter investigates knowledge sharing in collaborative work. Through two empirical studies of personnel working offshore and onshore in an oil company, the authors address the role of self-synchronization and boundary spanning as practices for improving collaboration in integrated operations. They focus on the following enabling capabilities for collaborative work: management, knowledge sharing, trust, shared situational awareness, transparency, and information and communication technology. This chapter is more concerned with the people, process, and governance aspects of a capability development process for integrated operations. The authors are especially interested in how self-synchronization and boundary-spanning practices emerge in a dynamic relationship with the identified enabling capabilities. Self-synchronization and boundary-spanning practices influence the enabling capabilities and vice versa. In the end the improved practices and the enabling capabilities are so intermingled that it becomes difficult to describe causal relations and effects.

Chapter 6
Teams: The Intersection of People and Organisational Structures in Integrated Operations 91
Dominic Taylor, Wipro Oil and Gas Consulting, UK

The success and sustainability of the Integrated Operations (IO) initiative within the Oil and Gas industry is discussed in relation to the ways people work together and the organisational structures which support that work. Whilst collaboration has become a defining concept in the industry for optimal working, this chapter argues that other characteristics found in the concept of teamwork are of equal importance in achieving the aims of the IO project. Teams and high-performing teams can provide a framework for understanding how groups of people within the workplace can respond to the dynamic environments of the oil and gas industry and fulfill the objectives of IO. The chapter presents some tactics for creating high-performing teams within this domain and presents two case studies to show the importance of teamwork in realizing the goals of Integrated Operations.

Chapter 7
Managing Team Leadership Challenges in Integrated Operations 103
Sjur Larsen, NTNU Social Research, Norway

This chapter gives an empirically based account of leadership of teamwork in Integrated Operations settings, or "IO teamwork" as it is termed here. First, a brief presentation of the characteristics of IO teamwork and its leadership is provided. Then follows an overview of relevant theoretical perspectives to the study of team leadership in IO settings. Next, central challenges regarding leadership of IO teamwork are discussed, and empirical examples of how leaders of IO teams go about managing these challenges are provided. Finally, directions for future research in this area are given.

Chapter 8
Implementing iE: Learnings from a Drilling Contractor 123
Martin Eike, Kongsberg Oil & Gas Technologies, Norway

On the Norwegian continental shelf, utilization of iE has been regarded as a vital measure for avoiding a rapid decline in production. Implementation has however proven to be challenging, and an unharvested potential still exist. Taking a capability approach to such implementation may help attain this remaining potential. Doing so requires a good understanding of what factors secure a successful and sustainable iE-implementation. Here, a case study of how a drilling contractor has adopted iE is used as basis for identifying such factors. An analytical framework rooted in the tradition of innovation theory is used for exploring the empirical material. The findings are further used as basis for presenting a set of recommendations that, if utilized, could help managers and change agents in their efforts of successfully implementing iE-capabilities within their organization.

Chapter 9
Good IO-Design is More than IO-Rooms..... 141
Berit Moltu, Norwegian University of Science and Technology, Norway

Integrated Operations' (IO) is about employing real time data and new technology to remove barriers between disciplines, expert groups, geography, and the company. IO has been associated with so called IO rooms. IO is technology driven, but is neither room nor technology deterministic. A network understanding of IO, based on Science and Technology Studies (STS), gives a process of different actants chained in networks, pointing the same directions by the same interests, to obtain the anticipated effect as is comes to efficiency and good HSE results. This chapter develops the seamless web of the IO design and describes good design criteria based on studies in Operational Support Rooms (OPS) in a Norwegian Oil Company. This process of the heterogeneous engineering of IO is not to be seen as technology implementation rather than technology development. This chapter points on how the seamless web of the IO design might contribute to good working conditions.

Section 3
Planning, Concurrent Design, and Team

Chapter 10
How to Implement Multidisciplinary Work Processes in the Oil Industry: A Statoil Case 155
Tom Rosendahl, BI Norwegian Business School, Norway
Asbjørn Egir, Astra North, Norway
Erik Rolland, University of California, USA

This chapter explores possibilities for using Concurrent Design at Statoil, seeking to understand how they should proceed in implementing this kind of work, and consider potential pitfalls of using this method. The authors offer ideas that can minimize the time required to implement the multi-disciplinary approach of Concurrent Design. Few companies have the requisite knowledge and skills required to implement this method effectively. Concurrent Design requires preparation and dedication to planning and implementation, along with adequate resources. It requires numerous changes in the organization's and in the employees' mindsets. Top management, department heads, project managers, and employees must adapt and change their work processes.

Chapter 11
Implementing Integrated Planning: Organizational Enablers and Capabilities 171
Lone S. Ramstad, MARINTEK, Norway
Kristin Halvorsen, MARINTEK, Norway
Even A. Holte, MARINTEK, Norway

Transferring the IO principles to the planning domain has led to the development of the concept of Integrated Planning (IPL). The concept represents a holistic perspective on planning, emphasizing the interplay between planning horizons, between organizational units, and among cross-organizational partners. Based on findings from three case studies, the purpose of this chapter is to present how three companies in the oil & gas industry has approached integrated planning, illustrating some of the challenges they have experienced in the planning domain. With the findings as a starting point, the authors identified three enabling factors that need a particular focus when implementing IPL: ICT tools, roles & processes, and arenas for plan coordination. In addition, the authors argue that in order to succeed in implementing integrated planning practices, as well as continuously improving these, human and organizational capabilities need to be cultivated, and focus here on four salient features of an integrated planning practice: competence, commitment, collaboration, and continuous learning.

Chapter 12
Promoting Onshore Planners' Ability to Address Offshore Safety Hazards 191
Ann Britt Skjerve, Institute for Energy Technology, Norway
Grete Rindahl, Institute for Energy Technology, Norway
Sizarta Sarshar, Institute for Energy Technology, Norway
Alf Ove Braseth, Institute for Energy Technology, Norway

With new generations of Integrated Operation, the number of offshore staff may be reduced and more tasks allocated to onshore staff. As a consequence, onshore planners may increasingly be required to address safety hazards when planning for task performance offshore. The chapter addresses the question of how onshore planners' ability to address offshore safety hazards during planning of maintenance and modification tasks can be promoted by use of visualization technology. The study was performed using the IO Maintenance and Modification Planner. Eight domain experts participated in the study, performing in all thirteen scenarios of 30-40 minutes duration. Data was obtained from system logs, participant interviews, questionnaires, and expert judgments. The outcome of the study suggested that visualisation of planned jobs on a geographical representation of the decks at the installation, in combination with indications of associated safety hazards, served to promote onshore planners ability to address offshore safety hazards.

Section 4
Cases

Chapter 13
Baker Hughes IO and BEACON with a Focus on Downsizing Personnel Requirements at Rig-Site 213
Joanna Karin Grov Fraser, Baker Hughes, Norway
Jan Ove Dagestad, Baker Hughes, Norway
Barry L. Jones, Baker Hughes, Norway

For more than a decade, Baker Hughes has developed a number of IO applications and WellLink technologies building its BEACON (Baker Expert Advisory Centre Operation Network) platform for the

digital oilfield. The scope of BEACON is remote access of real-time rig data, drilling data and wireline data, production and pump monitoring, and static file management. These technologies have enabled the company's collaboration centers around the world primarily to monitor, support, and optimize operations without having to be physically present at rig site. This development has been a foundation for a successful roll-out of remote collaboration and re-manning of operations, where Baker Hughes has reduced the number of personnel needed at rig site by 25-50%. Monitoring and remote supervision of real-time information 24/7 to optimize overall performance and paperwork (logging, petrophysical analyses) are now all done by people in the office using information communications technology to connect to the rig site. Larger-scale re-manning can also be done with services such as reservoir navigation, drilling optimization, pump management, liner hanger down hole technical support, et cetera. On the Norwegian shelf, where re-manning has been done at higher levels than in many other regions, nearly 50% of Baker Hughes' staff who would traditionally have been offshore can be re-manned during operational peaks – this means they are either in an office onshore, or their responsibilities have been changed. Baker Hughes' cross-training of personnel facilitates this flexibility, allowing for efficient and HSE-compliant re-manning.

Chapter 14

Integrated Operations in Petrobras: A Bridge to Pre-Salt Achievements 225
Claudio Benevenuto de Campos Lima, Petrobras, Brazil
José Adilson Tenório Gomes, Petrobras, Brazil

Known as an integrated energy company that operates in all segments of the oil industry, Petrobras has a broad management experience and uses a multidisciplinary approach, which applies to different areas. Recently, the impressive discoveries of the Pre-Salt reserves have created an exciting scenario in multiple aspects. Petrobras expects to produce more than 5 million bpd of oil by 2020, out of which only 1 million will come from Pre-Salt. This leads to an approach that will require scalable and sustainable solutions that take into account the better understanding of how people, processes, technology, and governance issues are connected and managed (Hendserson, J. et al., in this book). Considering past experiences and the complexity of the new oil and gas production scenario, Petrobras is preparing an even greater leap in its upstream operation and maintenance management systems – a corporate initiative called GIOp (acronym for Integrated Operations Management, in Portuguese) is being implemented. This chapter describes the implementation of GIOp in all upstream operational units of Petrobras in Brazil, considering the main organizational aspects, the methodology to develop a portfolio of opportunities, the scalability of the solutions, and the initial experience in Pre-Salt production.

Chapter 15

The Introduction of a Hand-Held Platform in an Engineering and Fabrication Company..... 246
Irene Lorentzen Hepsø, Trondheim Business School, Norway
Anders Rindal, Trondheim Business School, Norway
Kristian Waldal, Trondheim Business School, Norway

This chapter describes a framework that captures knowledge in an organization and applies it in daily operations. Knowledge capturing is one of the biggest upcoming challenges to oil and gas organizations as operations become more remote, more challenging, and many experts are leaving the oil and gas industry. A methodology is described to capture the knowledge of experts centrally and apply it throughout all operations in the organization. Due to the fact that an asset team is facing different constraints and challenges throughout the lifetime of a field, the system needs to gather experience from decisions and learn together with the asset team. Technologies that are flexible enough to process uncertainties are discussed as well as the effect on people, processes, and organization.

Section 5
Leadership and Learning

Chapter 16
Adaptive Advisory Systems for Oil and Gas Operations..... 262
Andreas Al-Kinani, myr:conn solutions, Austria
Nihal Cakir, myr:conn solutions, Austria
Theresa Baumgartner, myr:conn solutions, Austria
Michael Stundner, myr:conn solutions, Austria

This chapter describes a framework that captures knowledge in an organization and applies it in daily operations. Knowledge capturing is one of the biggest upcoming challenges to oil and gas organizations as operations become more remote, more challenging, and many experts are leaving the oil and gas industry. A methodology is described to capture the knowledge of experts centrally and apply it throughout all operations in the organization. Due to the fact that an asset team is facing different constraints and challenges throughout the lifetime of a field, the system needs to gather experience from decisions and learn together with the asset team. Technologies that are flexible enough to process uncertainties are discussed as well as the effect on people, processes, and organization.

Chapter 17
Integrated Operations from a Change Management Perspective 285
Tom Rosendahl, BI Norwegian Business School, Norway
Asbjørn Egir, Astra North, Norway
Lars Kristian Due-Sørensen, BI Norwegian Business School, Norway
Hans Jørgen Ulsund, Vitari, Norway

The purpose of this study is to investigate the factors that have been prominent in driving or restraining the implementation of Integrated Operations (IO) within the Norwegian oil industry - from a change management perspective. The authors focus on trends in implementing Integrated Operations across companies on the Norwegian Continental Shelf. The research is a cross-sectional case study, based on interviews with 15 respondents and the use of relevant documents. Findings are presented in a modified version of Lewin's Force Field Analysis. The authors have found multiple forces that have affected the implementation of Integrated Operations to various extents. This chapter focuses on three of them: Understanding the rationale of IO; Establishing support for change; and Technological solutions. Findings based on data gathered across multiple organizations in the Norwegian oil industry should yield a great potential for improving the future development and implementation of Integrated Operations.

Chapter 18
Knowledge Markets and Collective Learning: Designing Hybrid Arenas for Learning Oriented Collaboration..... 304
Bernt Bremdal, Narvik University College, Norway
Torbjørn Korsvold, SINTEF Technology and Society, Norway & Norwegian University of Science and Technology, Norway

In this chapter, the authors argue that "Knowledge Markets" might be used as a term to describe how individuals can be engaged in a democratic process where their competence, background, and personal information resources are mobilized in full in a broad and non-biased process. The contribution of each individual is aggregated and averaged in a way the authors believe will yield more accurate results, personal involvement, and learning than traditional approaches to group efforts. Recent work on

crowdsourcing (Surowiecki, 2004) highlights the strength of a collection of individuals over traditional organizational entities. This contribution will extend these principles to fit into an organizational setting. The chapter discusses how knowledge markets can create an arena for change. Moreover, it shows that if certain principles are observed desired effects could be achieved for relatively limited groups. The authors extend this to propose theories about collective learning and performance improvement. They further describe how the principles defined can help to meet some fundamental challenges related to petroleum activities such as drilling. The authors think that the Knowledge Market approach can serve as a model for designing IO arenas to increase collaboration, to improve shared problem solving, and make collective learning more effective. In all kinds of operations performance improvement is strongly related to learning. It is a cognitive ability that must be exercised and maintained through motivation, discipline, and other stimuli. Collective learning applies to the effort whereby a group of people detect threats or opportunities and learns how to take early advantage of this in order to assure change.

Chapter 19
The Terms of Interaction and Concurrent Learning in the Definition of Integrated Operations 328
Trygve J. Steiro, Norwegian University of Science and Technology (NTNU), Institute for Production and Quality Engineering, Norway & SINTEF Technology and Society, Norway
Glenn-Egil Torgersen, Norwegian Defence University College, Norway & Institute for Energy Technology, Norway

This chapter introduces a new definition of Integrated Operations (IO) adapted to the oil industry. This definition focuses on interaction. Such an approach is necessary to emphasize learning processes in the organization's various echelons. It is an important assumption for the success of IO as a flexible and complex organization. The term "Interaction" is elaborated with special emphasis on "Concurrent Learning." Such an approach ensure reflection during the process leading up - the way forward - to the target and the development of a more fundamental organizational philosophy rather than just focusing on the result. It will create a more robust "integration" between technology, people, and organizations so that a higher capability in integrated operations can be achieved.

Section 6
Resilience and HSE

Chapter 20
IO, Coagency, Intractability, and Resilience 342
Erik Hollnagel, University of Southern Denmark, Denmark & Norwegian University of Science and Technology, Norway

Technological developments continuously create opportunities that are eagerly adopted by industries with a seemingly insatiable need for innovation. This has established a forceful circulus vitiosus that has resulted in exceedingly complicated socio-technical systems. The introduction of Integrated Operations in drilling and off-shore operations is one, but not the only, example of that. This development poses a challenge for how to deal with risk and safety issues. Where existing safety assessment methods focus on descriptions of component capabilities, complicated socio-technical systems must be described in terms of relations or even functional couplings. In order to design, analyse, and manage such systems, it must be acknowledged that performance adjustments are a resource rather than a threat. Safety can no longer be achieved just by preventing that something goes wrong, but must instead try to ensure that everything goes right. Resilience engineering provides the conceptual and practical means to support and accomplish that change.

Chapter 21
IO Concepts as Contributing Factors to Major Accidents and Enablers for Resilience-Based Major Accident Prevention 353
Eirik Albrechtsen, SINTEF Technology and Society, Norway
Audun Weltzien, Norwegian University of Science and Technology, Norway

On the one hand, inadequacy of IO-concepts can, in combination with other factors, contribute to major accidents. On the other, work processes and technology within an IO-context contribute to prevent major accidents. This chapter shows how IO concepts can enable a resilience-based approach to major accident prevention by employing a case study of an onshore drilling center. Interviews indicate that drilling and well operations justify a resilience approach, as these operations are complex and dynamic. The case study shows how an onshore drilling support center facilitate adaptation to current and future situations at the sharp-end by providing decision-making support for the sharp-end by its ability to monitor what is going on, anticipate future developments, and look into past events and data. By use of the case study resilient capabilities and their required resources are identified. To ensure that inherent organizational resilience is managed and maintained adequately, there is a need to: 1) identify and refine inherent resilient capabilities and resources; and 2) develop methods and tools to manage resilience.

Chapter 22
Introducing IO in a Drilling Company: Towards a Resilient Organization and Informed Decision-Making? 370
Grethe Osborg Ose, Norwegian University of Science and Technology (NTNU), Institute for Industrial Economics and Technology Management/Norwegian Marine Technology Institute (MARINTEK), Norway
Trygve J. Steiro, Norwegian University of Science and Technology (NTNU), Institute for Production and Quality Engineering/SINTEF Technology and Society, Norway

The introduction of Integrated Operations (IO) in the offshore oil and gas industry makes distanced and distributed decision-making a growing part of normal work. Some functions have been transferred from offshore installations to onshore offices as a consequence of the technologies that have recently become available. The authors analyze whether the onshore organization is ready for increased responsibilities by increasing the resilience in its work patterns, since resilience is important for maintaining or increasing safety level compared to current operation, where personnel on board installations can observe the plant at first hand. This study has been performed as a case study of an onshore Support Center in a drilling company at the start of the process of using the Support Center. The establishment of the Support Center involved re-arranging the office arrangements to an open landscape for all offshore installation support personnel and grouping them according to disciplines. They also acquired new technology, including video conference equipment. Important findings are that developing resilience has to be followed through at all levels of the organization. Time and resources have to be made available when work practices change, providing the physical framework alone does not improve resilience. The study also offers a more detailed description of capability resilience and which aspects should be considered when developing resilience. The authors look at the status so far in the change process and also find areas that should be developed in order to increase resilience further.

Compilation of References 389

About the Contributors 414

Index 424

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Section 1
Introduction and Definitions

Chapter 1
What is a Capability Platform Approach to Integrated Operations?
An Introduction to Key Concepts

John Henderson
Boston University, USA

Vidar Hepsø
Norwegian University of Science and Technology (NTNU), Norway

Øyvind Mydland
Stepchange, Norway

ABSTRACT

The concept of a capability platform can be used to argue how firms engage networked relationships to embed learning/performance into distinctive practices rather than focusing only on technology. In fact the capability language allows us to unpack the role of technology by emphasizing its interaction with people, process, and governance issues. The authors address the importance of a capability approach for Integrated Operations and how it can improve understanding of how people, process, technology, and governance issues are connected and managed to create scalable and sustainable practices. The chapter describes the development of capabilities as something that is happening within an ecology. Using ecology as a metaphor acknowledges that there is a limit to how far it is possible to go to understand organizations and the development of capabilities in the oil and gas industry as traditional hierarchies and stable markets. The new challenge that has emerged with integrated operations is the need for virtual, increasingly global, and network based models of work. The authors couple the ecology approach with a capability platform approach.

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INTRODUCTION: THE MOVEMENT TO CAPABILITIES IN INTEGRATED OPERATIONS

The concept of a capability platform includes elements such as technology, process, people and governance issues and includes enabling core capabilities such as collaboration and leadership. One key characteristic of the platform concept is that innovation and change often occurs from outside to inside. That is, the ecosystem actors are often the source of independent innovations that are then absorbed into core operations. By coupling the notion of ecologies and platforms, we allow for an emerging model of integrated operations that recognizes the critical need of collaboration across traditional boundaries. In practice the technology solutions form the base of the platform with the more people, process and organisational dominant elements making up the top layers of the platform stack. We describe the content of such a capability platform in relation to integrated operations and present how it can be developed to create sustainable and scalable practices.

Over the last ten years integrated operations have gone from initiatives started by enthusiasts, through pilot testing and broad implementation of new IO practices. Some efforts of implementation of IO have been scalable and sustainable; others have never been able to pass the general adoption threshold or chasm (Hepsø. et al 2010) of piloting and good intentions. Some of the early work on IO was technology biased and was treating human and organizational issues as a remaining factor (Hepsø 2006) or heralded that integrated operations was all about people and processes and nothing about technology. One key notion of the IO model is that work is highly distributed; across geography, disciplines and cultures. Integrated Operations is thus a strategy to achieve effective collaboration among many companies and work sites. Following the lessons learnt (i.e., Edwards, et.al 2010) over the years we see that there is a need to address the human, process, governance and technology issues of integrated operations through an integrated approach[1]. The capability platform concept is one such approach. It can be used to understand how firms engage in networked relationships to impact learning / performance and develop distinctive practices rather than focusing only on technology. In fact the capability language allows us to unpack the role of technology resources by emphasizing its interaction with people, process and governance resources. Given that the organization exists in a networked setting with heterogeneous resources, the challenge is how to configure the firm's resources into scalable and sustainable capabilities that achieve desired actions and outcomes.

When most major oil companies and globally operating service companies address their future way of doing business as oil exploration and operation enabled by information and communication technology there is a certain logic behind this vision (OLF 2005); a bundling of the company resources to configure sustainable capabilities: integration of people across geographical, organizational and disciplinary boundaries, integration of processes in terms of business integration and vendor collaboration and finally; integration in relation to technology: data, sensors, protocols, fibre optics, standardization and others. This vision of integration of resources into capabilities is seen in a typical definition of an e-field; an instrumented and automated oil and gas field that utilize people and technology to remotely monitor, model and control processes in a safe and environmentally friendly way in order to maximize the life value of the field, see Figure 1. Over the last decade, the ability to enable people and teams to work in different ways has been influenced by many drivers (Edwards, et al 2010). New oil discoveries tend to be in places far away from the key skill centers. There a key skill shortage brought about by an increasingly aging workforce. Further, new

discoveries are technically more challenging and there is an accelerating focus on production efficiency, reservoir recovery and cost-containment. In our view, the concept of a capability platform operation within an information ecology provides a coherent and practical approach to meet these challenges.

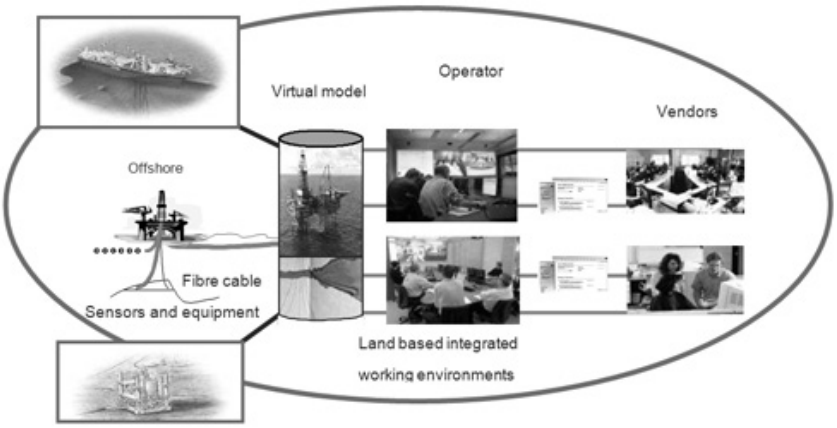
In this chapter we try to address the importance of a capability approach for integrated operations and how it can improve our understanding of how people, process, technology and governance issues are connected and managed to create scalable and sustainable practices. We describe the development of capabilities as something that is happening within the 'ecology' of the oil and gas business and beyond. The structure of the chapter is as follows. We start by defining an information ecology and link this concept to capabilities. Then we argue that a capability approach is different from a process approach. After this we expand our notion of a capability platform and provide examples of layers or niches in this platform. A case is presented where the concepts are illustrated. In the end we present some guidelines for steps to be taken for using a capability development approach in a green field development project.

INFORMATION ECOLOGIES AND CAPABILITIES

The concept of an ecosystem or ecology is increasingly used to depict the dynamics of the emerging situation associated with integrated operations (Hepsø, 2006). To better understand this concept we must first explore some important foundational principles of an information ecology. An example of an information ecology is depicted in Figure 1.

There are three bundled configurations of heterogeneous resources that have facilitated the development of distinct capabilities in this information ecology. First, is the continuous development and increase of data transfer networks, from low bandwidth satellite onshore-offshore communication to fibre-optic networks that enable Giga and Terra bits of real-time data (video, audio, data control and steering, monitoring data and 3D pictures/models).. This configuration also includes embedded new sensor technologies in ways that greatly enrich the information potential of the shared data. In our perspective of capabilities, this network foundation is not just a configuration of hardware and software but also the human, process, and governance resources

Figure 1. Integrated Operations, from reservoir and process facility sensors to integrated collaboration among operators and vendors (OLF 2005a). Figure courtesy of OLF (Norwegian Oil Industry Association).



required to make effective sharing of data over time a reality. With this configuration, individuals in different locations, working for different companies can access and/or manipulate the same data at the same time, see Figure 1.

The second configuration that enables the development of this information ecology is standardization of telecommunication software/hardware platforms and data exchange formats as that based on XML-schemes (WITSML, PRODML and OPC UA) and model driven software development that has eased the integration of data. This also cannot be understood as a purely technological process since it involves standardisation, politics and severe governance challenges.

The final configuration of resources reflected in Figure 1 is the ongoing convergence between computing and telecommunications, and the development of collaboration tools/software, like videoconferencing, unified communication, smart boards, instant messaging, social software and 3D visualization that have made communication across distance easier. These three configurations of heterogeneous resources form the backbone infrastructure for integrated operations. What makes the integrated operations infrastructure different from a traditional IT infrastructures has been noted Edwards (2010) and others (REF'S) and includes a move to a real time or near real time way of working, the connection of one or more remote sites or teams to work together, and finally, a move to a more multi or interdisciplinary way of working.

We argue that capability development is linked to an ecological model of work and organization. Using 'ecology' as a metaphor acknowledges that there is a limit to how far we can go to understand organizations and the development of practices as traditional hierarchies and stable markets. In the emerging reality of the oil and gas industry, "operations" is virtual, increasingly global and network based. An information ecology is a system of people, practices, and technologies in a particular "local" environment (Nardi and O'Day 1999: 50-55). Note that local here means both virtual and real presence in networked virtual environments. Virtual, local and global are key features of an information ecology that are not often present in a traditional ecology bound in a particular space. Even though an information ecology has complex dynamics with diverse species and contain opportunistic niches for growth, it can, as a virtual space, be scaled down to individuals. It allows each professional to find her/his perspective, set up possible paths into a larger system and shows ways to intervene in this larger system.

Nardi and O'Day argue that diversity, in terms of different species, is necessary for the growth of the ecology to be sustained under the threat of chaos and change. Diversity captures different roles, education, experience and organizational identity. Information ecologies evolve when new ideas, technologies, activities, market opportunities and forms of expertise arise in them. Nardi and O'Day (1999:50-55) argue that people participate in the on-going development of their information ecologies and as they learn, adapt and create, so will their relations to their tools and technologies. They write: "Even when tools remain fixed for a time, the craft of using tools with expertise and creativity continues to evolve. The social and technical aspects of an environment co evolve. People's activities and tools adjust and are adjusted in relation to each other, always attempting and never quite achieving a perfect fit". The concept of a capability platform with its emphasis on the interplay between people, process, technology and governance and its inherent focus on network driven innovation offers a design perspective that is consistent with this view of Integrated Operations as a complex information ecology.

WHY CAPABILITIES IS NOT ANOTHER WAY TO DESCRIBE BUSINESS PROCESSES

The concept of capabilities is an extension of the long history of process thinking in organizations. A process is a set of activities or work flow with a specific beginning, a well defined end point and a clear and measurable goal. Business process thinking has become a corner stone of Integrated Operations and, more generally, total quality initiatives. Process based thinking also plays a critical role in the design of work processes that extend across organizational boundaries. These inter-organizational projects often require innovative thinking and lead to transformation of a business model. The rise of process thinking was motivated, in large part, to overcome the silo mentality associated with traditional IS applications. However, as organization pursued transformation using a process design logic, they began to realize that success requires much more than a well defined "to be" process. The challenge of transformation requires alignment of process, people, technology and governance. The complex interactions among these four dimensions must be addressed for successful business transformation.

The notion of a capability emerged as an explicit attempt to cope with this complexity. Kogut and Kulatilaka (2001) define a capability as the interaction of process, technology and governance. In a subsequent paper, Henderson and Kulatilaka (2008) argue that capabilities include both governance mechanisms and people oriented issues such as culture or values. The resulting definition of a capability is a set of interdependent activities involving people, process, technology, and governance that directly creates economic value. This definition has two key elements. First, the value of a capability is defined in a manner that explicitly impacts a business outcome. While internal customers may be involved, business value is always defined in the eyes of an ultimate customer. Thus, a capability logic flows from outside – in, never inside-out. Secondly, a capability is the synthesis of people, process, technology and governance. No single dimension is more important than another. One may be easier to achieve, e.g., it may be easier to deploy technology than to change culture, but both are required for success. This is a critical concept because value arises from the synergy of the four dimensions, not the singular effect of each individual one. A debate over the relative value of people versus technology misses the point that both are required and can needlessly side-track the transformation effort.

Each dimension must be understood in the context of the transformation effort. Process definition focuses on the work flow and is often the starting point. A traditional design process that evaluates the "as is" versus "should be" is still an effective methodology. However, capability thinking requires a continuous iteration among the four dimensions to be sure that the true complexity and conditions for success of the process are understood. For example, a process design may differ significantly under the assumption of unlimited bandwidth, universal connectivity or embedded sensors. Thus, the opportunities afforded by the interaction of process and technology must be carefully considered from the perspective of the customer.

It is important to note that a capability is not static. Rather, building on the view that a capability platform is an information ecology, these dynamic nature of capabilities allow for innovation emerging from these capabilities. Technology in a capability platform is an enabling device for people, process and governance. Alone, technology seldom drives value. But when combined in a creative manner with these other dimensions, technology can enable radical transformation. In today's world, the reality of convergence and the price point for network centric design offers exciting possibilities to move the center of gravity of the organization to the edge. In an edge

organization peer to peer connectivity can be used to transform both organizational structure and process (Skarholt, et.al 2009; Næsje, et.al 2009). Emerging technology offers the opportunity to change the role of the participants and create a model of innovation in which valuable products and services are co-developed. Such capabilities, enabled by technology that can achieve this vision are truly transformational. Let us make this more explicit. Digital infrastructure of the kind brought up by IO has features of generativity (Tilson, et.al 2010; Zittrain 2008). Generativity denotes an ability to create, generate or produce a new output, structure or behaviour without any input from the originator of the system. As Zittrain (2008: 43) argues such infrastructures are built on the notion that they are never fully complete and many new uses yet to be conceived of. There are unforeseen properties that must be handled in a development process. Such infrastructures have the ability to recombine data sources and semi-automatically generate, assemble and redistribute content. This generativity also allows people in the ecology to create new services, applications and content.

People are, of course, the centre of value creation for most organizations. The concept of core competencies is, in large part, a testament of the value embedded in the culture, knowledge and creativity of people. Technology enables people to connect and execute in new and efficient ways. Process creates both the efficiency and reliability that is vital to grow. Together, people, process and technology form the foundation of value creation for the customer.

Governance brings into the design process both the tension between local and global goals and the issue of ownership. Local versus global goals is a traditional tension between the corporate interest and the edge of the organization where performance demands may conflict with global goals. Local goals can also reflect the needs and desires of an individual rather than those of the enterprise. Regardless of the source of tension, all designs must find a reasonable balance between local and global goals. Hence organization is always part of a design process.

A final comment is in order. A capability perspective is more complex than a pure process oriented design methodology. The question is how to effectively deal with this increased complexity. Three approaches appear to enhance the implementation of this concept. First and most important is focus. There must be a planning process that focuses the transformation on those core capabilities that truly define value in the eyes of a customer. A transformation initiative that seeks to change too many capabilities is too complex and to poorly understood. In the end, if you have to create ten new capabilities to transform your business, you still have not answered well the basic question "what drives value in the eyes of my customer".

Secondly, the design process requires an iterative approach. Most often, it begins with a high level process analysis and then attempts to redefine the process in ways that maximizes both customer value and shareholder return. There are many ways to implement this iterative approach but the key is to make sure the process of design is driven by customer value.

Finally, creating capabilities is often a co-development process involving customers and/or partners. By definition this process involves strategic learning. A key to successful capability transformation is the design of a platform that allows for rapid development and deployment of new products and services while maximize strategic learning. This platform will evolve and serve as an efficient engine for execution of the capability while also allowing for continuous innovation from outside – in. Generativity is a key feature that must be taken into this process. A key to value capture is to control the architecture of this capability platform, see also Yoo, et.al 2010 and Tilton, et.al 2010 for more on these matters.

FROM INFORMATION ECOLOGIES TO CAPABILITY STACKS AND PLATFORMS

The capability platform becomes a way to connect the design of organizations to the concept of ecology. Capability thinking helps us to recognize that unlike product platforms, interfaces are often embedded in people or processes much like that of relationships in ecosystems. These interfaces are often social and cannot be predefined hence require the notion of work to explicitly address people and governance and most importantly recognize the importance of continuous learning, adaption and innovation. This is also an important issue of generativity as we already have discussed.

The concept of a platform is not new. A formal definition of a platform address two key concepts; first, a platform provides reusable functionality so as to achieve a productivity gain in subsequent innovations or applications, and second, a platform provides an easy interface or mechanism that enables ecosystem actors to independently develop and offer distinctive functional services. The concept of platforms has been well developed for product design. Cusumano and Gawer (2002) define a platform as "an evolving system made of independent pieces that each can be innovated upon." The core notion is that the system (or product) can evolve via the efforts of many independent agents rather than one centrally controlled agent or team. However, this ability for a system to evolve via independent module innovation requires that each module has a defined and stable interface point. These stable interfaces allow other modules or designers to access functionality regardless of the inner workings of the module. The result is a plug-and-play environment that fosters adaptability and innovation. Recently we also see that there is an emerging trend of digital infrastructures that address platform strategies (Yoo, et.al 2010: Tilton, et.al 2010).

Of course, not all modules play an equal role within a system. Boudreau and Hagui (2009) argue some modules provide a core set of functionality and, as such, can provide significant economies of scale via common use. These core modules often determine the standards and interfaces used by most independent module developers. All ecosystem partners gain efficiency by using the core. They differentiate their modules by providing a value-added functionality to the whole system. In this chapter, we seek to extend the logic of a product platform to that of an organizational capability platform. The platform logic allows a view of the organization that directly addresses the existence of a coherent ecology. That is, a group of independent companies that creates complementary value through direct and indirect collaboration.

In essence, the core functionality of the platform provides a basis for the effective collaboration of the broader ecology. From a business perspective, this ability to effectively engage collaboration across boundaries without imposing a command and control coordination process enables significant increases in flexibility and innovation and with this increase the potential for generating enhanced performance. In large organizations or very complex work environments, we need to realize the solution will not be provided by one meta-platform. Rather much like the computer industry coped with the complexity of very large systems through layering, we argue for a capability stack view service as a broader view of the IO ecology. This approach allows us to explore the true complexity of the ecology while also providing an organizing perspective that can be used to design, integrate and deploy scalable and reliable solutions.

Given this starting place for the concept of a platform, we now provide a more formal definition of a capability platform. A capability platform is a set of capabilities deployed by multiple parties in a manner that:

1. Creates economic options value through design efficiency and flexibility.
2. Creates economic value though network effects generated by the ecology of organizations and individuals providing complementary of goods and services.
3. Has explicit architectural control points that enable relevant stakeholders to systemically capture portions of the economic value that has been created.

Not all product or service solutions require platforms strategies. In some cases, for example, the value of flexibility or the ability to leverage complementary services may be of marginal value. If one needs to dig a hole, he or she might be quite satisfied with a standard shovel. It is low cost, easy to use, requires little specialized expertise, and meets users' immediate needs. If in the future a different kind of ditch digger is required, the user could easily discard or store the shovel and buy another solution. That is, the cost of a flexible solution delivered by a platform strategy may exceed the value of a series of dedicated specific solutions. Flexibility is not free.

However, in a highly distributed, networked market, the value of both flexibility and complementary goods and services is often high. Our definition of a platform recognizes two aspects of the value proposition. First, a platform must create distinct value through both flexibility and network effects. Second, there must be an explicit control point that can be significantly influenced by the platform stakeholders. The first two conditions provide the economic rationale for a platform. The last condition focuses on who will capture the value created by the platform.

The concept of a capability stack provides a basis for exploring the dynamics of an information ecology. The strength of the ecology analogy is that it provides the language to represent the potential for value creation that emerges from diversity. The value of this diversity becomes even more apparent when combined with the power of capability platform models that reflect networked based innovation processes. The challenge is to cope with the inherent complexity of the ecology model. The capability stack model is a strategic lens to cope with this complexity. A stack model is a layered representation of a complex system. The stack model seeks to decouple the complexity of the system by introducing distinct layered activities connected by standard interfaces. In addition the stack model imposes a ordering or hierarchy. That is, the stack model assumes that capabilities at lower level are required to execute capabilities at a higher level. A layer uses defined interfaces that limit the impact of change. As long as the information representing the change can be exchanged across a layer via the standard interface, the innovation within one layer can be decoupled from innovation any other layer. As with any general notion of modularity, this decoupling allows for independent actions and thereby reduces the complexity of coordinating interactions across a system. In this way a stack model reflects the characteristic of ecologies wherein one part of the ecosystem can change without affecting all parts of the system.

Layered models are often used to represent the complex interactions in technology markets (Yoo, et.al 2010 and Tilton, et.al 2010). The complexity created by modern information solutions has resulted in a set of distinct product/service, e.g., hardware, telecommunication, operating system, linked together by industry standards. A strategist or designer can make sense of the industry, understand competitive dynamics, and position his or her product in the market using this stack model. Stack models have also been used to describe the range of capabilities required to deploy an organizational strategy. For example, Gerstner (2002) in the book on his years at IBM used a stack model to describe how he implemented his service oriented strategy.

Of course, using a stack model to represent a complex system does have limitations. The actual complexity of interactions between firms in the

technology market does not strictly adhere to the espoused stack model. In any organization, the interactions among people charged with the execution of a capability will surely cross layers in many ways not obvious from any single depiction of a capability stack. However, the value of the capability stack is that it allows the leader or designer to convey focus. Each layer represents a core set of activities. The complex interactions among this core can become the focus of the capability design, separating it from the complexity of designing capabilities at other layers. While far from perfect, this ability to establish a strategic focus for the design of a capability platform provides a viable basis for taking specific decisions that create and deploy the people, process, technology and governance resources of the firm.

The definition of a layer in a stack model must meet the following four criterions:

1. Each layer must have a dominant or compelling value proposition. While there may be a variety of product or service solutions, the focus of the layer should be clear. For example, a hardware layer and the operating systems layer have distinct yet different core value propositions even though they are adjacent layers in the information technology stack. The inability to state a dominant value proposition suggests either an immature or emerging layer or a weak link to a business strategy.
2. Each layer must have clearly defined and shared interfaces with adjacent layers. Often termed standards, the interfaces provide the mechanism to decouple layer and enable independent yet scalable innovation. There may be competing standards although as a layer matures, one or two dominating standard interfaces normally emerge.
3. Each layer must reflect an active market of product or service solutions. This market provides the source of significant innovation as well as it creates the option for any firm to scale services or acquire services at this layer. The stack model provides one means to model the competitive characteristics of a business ecology.
4. Each layer much have a well-defined business oriented set of metrics that reflect the core value proposition. As always, the ability to translate a value proposition into an appropriate set of metrics is a clear indicator that the definition of the layer is understood at a practical level.

In practice the technology capabilities form the base of the stack with the business operational capabilities making up the top layers of the stack. Note that we do not argue the lower levels of the stack are just technology. While the label describing a layer may emphasize the technology dimension, the deployment of the capability in this layer requires all four components. For example, we may label a layer as "communications" because the primary value created in this layer is the capability to exchange information or data. However, one only has to reflect on the activities required to provide a communication solution to recognise the array of people, technology, processes and governance that is required to be successful.

The Layers or Niches in a Capability Platform

We argue that there are a number of layers or niches that can be used to provide a strategic view of the ecology of integrated operations. For our purpose in this chapter we argue that there are five basic niches (read layers) in such an ecology:

- Technology resource layer
- An intelligent infrastructure
- Information and collaboration layer
- Knowledge sharing and analytics layer
- A business operations layer

A technology resource layer comprises capabilities to deploy and operate the basic technology elements and equipment needed to move hydrocarbons from the reservoir to the market (tubing, valves, XT's, separators, and pipelines). For heuristic reasons we say this layer does not include sensors and ICT-capabilities and is mainly components made out of steel. Of course the ability to deploy, maintain and adapt this technology resource layer requires distinctive people, process and governance as well as technology components.

An intelligent infrastructure enables increasing automatic monitoring due to sensing capabilities, like condition monitoring of facilities, down-hole sensing in wells and permanent ocean bottom seismic for geophysical reservoir monitoring. In today's oil and gas fields, this is an emerging infrastructure layer that enables a higher degree of instrumentation, automation and sensing to control oil and gas assets from the reservoir, via the wells, the process and support systems topside/ subsea from a distant location. This intelligent infrastructure needs the technology resource layer since in most cases the intelligent infrastructure is hardwired into the technology layer. However, this is not just the hardware infrastructure. Just as important are the people, organizations, skills, processes and governance that make this intelligent infrastructure work. This is therefore the second niche.

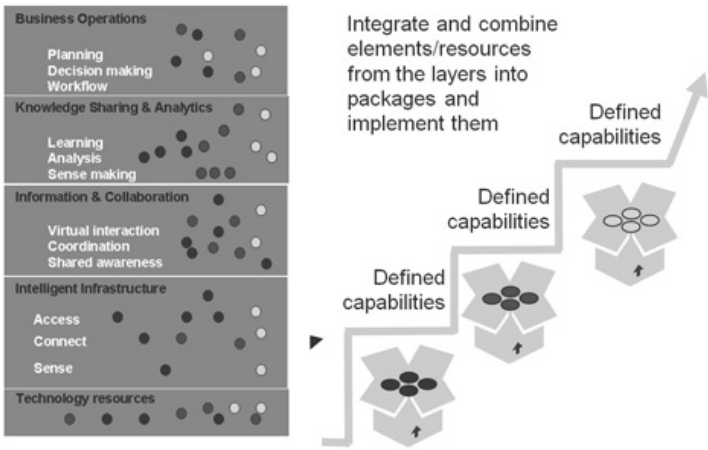
A safe and reliable data communications and infrastructure must exist if sensor data is to be collected automatically from reservoir and topside facilities and be used in the assets production processes. Movement of data from one locale to another must be enabled. This brings forth the need for an information and collaboration niche. This niche also consists of people, organizations, skills, processes and governance that make this niche work and sustain itself. The integration of this niche or layer with the next niche is pretty seamless and may in some cases be combined. The knowledge sharing and analytics layer enables real-time processing and analysis that is increasingly required for effective operations of an instrumented field. Knowledge sharing and analytics ranges from right-time updates of geo- and reservoir models, integrated production and process optimization tools, tools for well planning and drilling optimization, and condition-based maintenance applications.

Finally, the business operations niche or layer addresses the development and execution of work processes and decision support to enable the realization of performance. It is easier to see the people, organizations, skills, processes and governance in these latter two niches as well as the critical need to sustain themselves through innovation and adaption.

For each of these niches (layers) there will be different industry players or key species. New niches can grow out of existing niches or some key species can come to dominate several niches. The development of integrated operations can be seen as the development of new market layers where various companies try to increase their market-share in a niche, even moving beyond the starting point in the ecology. This means that the stack model environment (business and its market) is an ecology, consisting of niches which are layers in the stack. For each niche there are some dominant species. Sensor and hardware companies dominate the intelligent infrastructure layer. The "information and collaboration" and "knowledge sharing and analytics" layers are typically dominated by a different type of companies: software integration companies. In the end there is an emerging or changing market niche that drives the development within the other niches. Oil companies will have to fill all niche/stacks if they want to develop excellence in integrated operations. At the same time they form networks with companies inhabiting different parts of the niches/layers in the ecology.

Figure 2 shows that for each step you take you will need an integrated set of capabilities that can be scaled across a global business and provide a platform for continuous improvement and innovation

Figure 2. Example of a stack model capability platform without the market



ROADMAP TO DEFINE A CAPABILITY STACK

How can an organization systematically develop a capability stack? To focus our discussion of this proposed methodology, we illustrate that application of a capability and stack thinking for a green field operation. Let us first start by saying that such a development process will always happen within some physical, demographical or infrastructure constraints. Physical considerations that cannot be escaped are: Arctic, land, subsea and deep-shallow water. The characteristics of the reservoir can also differ, carbonate, sandstone, oil or gas condensate. Process complexity to produce the hydro-carbons will be another constraint.

A field with dry gas will be simpler than an oil processing platform. Drive mechanism is another; depletion is different from gas injection and water flooding. Remoteness to infrastructure is a third that will challenge not just infrastructure conditions but also the possibility to have easy access to human and other resources. Finally, there will be value and business drivers that will take business objectives, profitability and value into question. Net-present value investment calculations will always constrain your options. Today all oil companies have sophisticated methods to evaluate such potential field development solutions based on these types of key constraints. It is integrated in the concept development phase and in the business processes of planning a new field. Building a capability stack will never replace concept development and good engineering practices. Still, concept development is hardly seen as a capability development process by engineering and oil companies today. The key insight is that all these constraints can be looked upon as resources that have to be figured to fit the local green field under development. Ideally one wants a set of configurations or classes that reflect best practice solutions for typical combinations of constraints, and a method for putting them together in flexible ways for the best possible outcome.

Before we continue with the examples we introduce a roadmap for how an organization can develop the capability stack. The roadmap for preparation and planning is divided in 5 steps.

Step 1: Operational context

- Define the operational context that will constrain capability development.
- What is different or special with the specific operational context?

- What is the key constrains and what are the expected performance?
- What class of configurations can be used to structure a best practical solution?

Step 2: Define core capabilities

- Define the core capabilities that are most important to deliver performance.
- What are the core competencies to build in the firm to deliver the core capabilities?
- Based on the key core capabilities what are the key support capabilities?

Step 3: Develop the sub-layers and sub-capabilities

- Elaborate each of results from Step 1 and Step 2 to define the capability sub layers and the sub capabilities.

Step 4.: Evaluate and define capability resources and possible sourcing alternatives

- Create a business value metric for each defined layer and conduct a business case analysis to evaluate alternative capability investments and alternative sourcing models to deliver the set of capabilities to deliver the expected performance. (Table 1- Statoil IO Criteria's).
- Define and determine how to deploy both foundational/analytics capabilities and the structure of each resource is design for scaling

Step 5. Implementation plan

- Develop an implementation plan.

Roadmap Example, a Capability Stack for a Green Field Operation

One configuration of a field could be a deep-water subsea to beach gas field with a long pipeline. This configuration will have dry gas and an onshore processing plant. Examples of such a configuration are Snøhvit and Ormen Lange in Norway.

Step 1: Operational Context

Resources needed to develop such a field would range from reservoir characteristics, flow-lines, simulation tools, subsea equipment, fibre optic cables, people and governance models. It will be how the resources are put together for the best possible outcome that will provide the foundation for the green fields key capabilities. The operational context could be further defined by answering the following questions:

1. What is different or special with the specific operational context as total and for each part of the operation?
2. What are the key constrains?
3. What is the expected performance?
4. What are the key success criteria for the asset?

Step 2.: Define the core capabilities

We said earlier that a capability approach and a business process approach are complementary. Let us now come back to this. In the case of developing a configuration of this kind there are three major decision processes that will provide the key input to both business processes and core capabilities. This means that the ensemble of resources has to be organized in a way to make sure that these outcomes are handled. What are the core capabilities and the expected performance outcome, related to the operational context and the resources available? We have to start with defining the key decisions that the asset needs to take in order to meet its objectives. For a gas field like Ormen Lange or Snøhvit these typically are:

1. What decisions must be taken to deliver gas to market according to short and long term contract commitments. These decisions can be decomposed to understand two other sub-capabilities of the gas field configuration in question:

   a. **Subsurface/subsea/pipeline:** What decisions must we take in order to deliver well-stream to the receiving facility to meet short and long term commitments?
   b. **Onshore process plant:** What decisions must we take in order to deliver process capacity to process well-stream and export produced gas?
2. What key skills are needed to take the decisions?
3. What key information is required and at what frequency?
4. What is the proposed governance structure, that is, how will the responsibilities for these decisions be distributed or shared among the operating partners?

Without going further into the details of the examples of Snøhvit and Ormen Lange projects we see three core capabilities:

1. A value chain and market optimization capability
2. A process optimization capability
3. Well and pipeline optimization capability.

Each of these capabilities will have a technology element (all physical installations, equipment, IT and data, process element (business process, roles and responsibilities), people element (skills, competence, leadership) and organisation/governance element (organisation, business structure, agreements, rules and regulations).

Bear in mind that the key decisions, skills and information of the asset should be the starting point. There are other decisions not related to production and value chain optimization but we have chosen to focus on this domain in our example. We can increase the level of granularity and flesh out other major decisions that has to be met both for well/pipeline optimization and process/market optimization but we leave this for now, see Figure 5.

Step 3: Develop the sub layers and the sub capabilities

Elaborate each of results from Step 1 and Step 2 to define the capability sub-layers and the sub- capabilities needed to deliver the expected performance.

The core operational capabilities can be further decomposed based on the main decisions in Figure 5. What level of granularity to be needed will depend upon the situation. In order to simplify our discussion, we use a capability stack example with 3 layers. The technology and intelligent infrastructure is merged into a foundational layer and the information & collaboration layer is merged with the knowledge sharing & analytics layer into the analytics and collaboration layer.

To support the core capabilities layer, there are two major types; (1) analytics and collaboration capability and (2) service capability focused on supporting facilities, technology and information management. They all share the same four piece holographic structure. Technology will play a minor role in a collaboration capability, compared to people and process. Data will have a high technology component but still have an important governance part, i. e data management.

Lilleng (Lilleng & Sagatun 2010) argue based on the extensive experience with IO in Statoil that there are 7 independent criteria that should be used to evaluate the development of IO, see Table 4. These criteria can be used during the process of defining capabilities both within and across the layers in the stack. In this way, the stack model represents the necessary and sufficient conditions for effective value creation by IO, see Table 1. Note that we have illustrated how the layers of our capability platform can be integrated with Statoil's 7 criteria.

To be able to see how the four elements, people, process, technology and governance, relate more in detail to the major decisions we suggest linking the key core capabilities to a template that depicts the relationship among the elements. For our purpose we define the following layers in the capability platform;

Figure 3. Link between the generic stack model and the 3 layered simplified capability stack

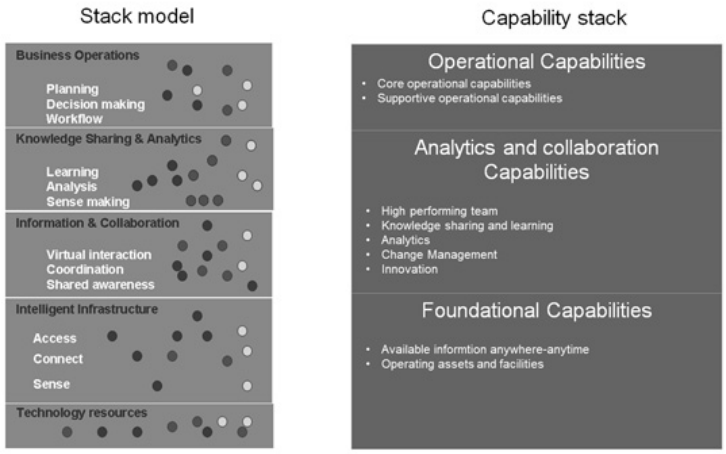


Figure 4. Operational, analytics/collaboration and foundational capabilities

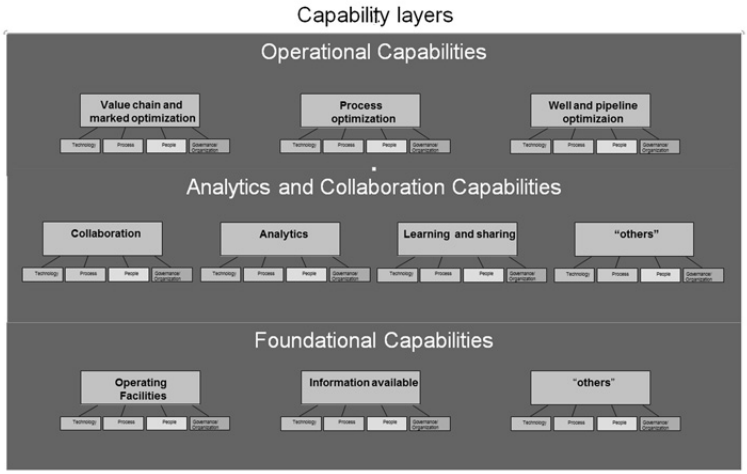


Figure 5. Key decisions for well/pipeline optimization and process/market optimization

Well and pipeline optimization

- How do we allocate production?
- How do we plan short-term production and long term recovery?
- How do we report production volume?
- How do we surveill the wells and pipeline?
- How do we do well testing and performance updating?
- How do we address flow line routing?
- How do we prioritize work and maintenance of the wells to maintain well integrity?

Process and market optimization

- How can we ensure the proper product quality of the gas?
- How can we utilize wells and production equipment in the best manner?
- How can we coordinate utilization of the total capacity and resources of the asset?
- How can we address quality assurance to estimate production loss and production potential?
- How do we control operational costs?
- How do we know and maintain technical condition of the facility?
- How do we maintain and improve the HSE level?

Table 1. The relationship between Statoil's IO-criteria and a simplified stack model

Statoil IO –criteria (Lilleng & Sagatun 2010)	Simplified capability model
Mind-set, leadership and training IO mind-set with transparent leadership, new ways of working and integration competence Focus on continuous change management Observation and analysis of operational practice to improve efficiency and improve formal requirements to roles and work practices. Training for all personnel in work process and collaboration training. Make sure that all team members have the technologies and interfaces at hand to make access to the information and connecting to other team members quick and easy	**Operational Capabilities** The niche of *business operations* addresses the development of new work processes and decision support to enable the realization of the three other areas. It also includes the necessary training, competence assessments, all sort of change management efforts and continuous improvement issues
Organization, networking and work process framework Networking of people and defining who to involve in each part of the work process, with competencies, mandates and decision authorities Harmonised work processes for key work processes A common operational model with support centres	
Collaboration work arenas Make sure that all team members have the technologies and interfaces at hand to make access to the information and connecting to other team members quick and easy An operational decision arena that is both physical and virtual Collaboration rooms with videoconferencing and general desk-top video conferencing (unified communications) that makes it possible to link up resources regardless of location onshore/onshore, local or global	**Analytics and Collaboration capabilities** Real-time processing and analysis is necessary to be able to handle the instrumented field data that are made available by the ICT infrastructure in order to derive the full benefit from the data. Knowledge sharing and analytics ranges from right-time updates of geo- and reservoir models, integrated production and process optimization tools, tools for well planning and drilling optimization, and condition-based maintenance applications
Information visualization and workspaces New information access solutions support more proactive and cross disciplinary use of information where data is presented and visualised as relevant information for targeted roles. Shared workspaces, data portals and visualization solutions Shared workspaces display a hierarchy of multi sourced synchronised information, including real time data, event recognition links to underlying databases and defined templates that support particular workflows	
Information access Make data available based on role based criteria anywhere Increased automatic file transfer and interoperability between large number of trending, modelling and interpretation applications and engineering tools. Service oriented architecture and web services Acquisition of sensor data from a variety of sensors down-hole, subsea and topside locations Data management and clean-up of underlying data sources	**Foundational capabilities** **Information and communication** A safe and reliable data communications and infrastructure must exist if sensor data is to be collected automatically from reservoir and topside facilities and be used in the assets production processes. Movement of data from one locale to another must be enabled. This niche also consists of people, organizations, skills, processes and governance that make this layer work and sustain itself **Intelligent infrastructure** An *intelligent infrastructure* enables increasingly automatic monitoring due to sensing capabilities, like condition monitoring of facilities, down-hole sensing in wells and permanent ocean bottom seismic for geophysical reservoir monitoring. There is an emerging infrastructure that enables a higher degree of instrumentation, automation and sensing to control oil and gas assets from the reservoir, via the wells, the process and support systems topside/subsea from a distant location. However, it is not just the hardware infrastructure. Just as important are the people, organizations, skills, processes and governance that make this intelligent infrastructure work. **Core technology resources** The basic technology elements and equipment that is necessary to move hydrocarbons from the reservoir to the market (tubing, valves, XT's, separators, pipelines) without sensors and ICT-capabilities
Communication infrastructure, data transmission and standards Communication and data transmission networks locally (WSN,WLAN) and regionally (fibre, radio links, WiMax, satellite) Integration between process control/safety systems across sites and information transfer between process near and admin IT systems. Increased focus on IT security standards Machine readable XML-communication standards (WITSML, PRODML) and others (SIIS, OPC UA) Object based data models (IA 88, isa 95, ISO 15926) and ontologies	
Data capture and remote activation Acquisition of sensor data from a variety of sensors down-hole, subsea and topside locations Wired and wireless acquisition Data measurement reliability, maintenance of instrumentation systems, data quality QA	

- **A operational capability layer:** Collaboration arenas, organization, networking and work process framework plus mind set, leadership and training in Statoil's model
- **Analytics and collaboration capabilities layer:** Information and collaboration (information access in Statoil's model)Knowledge sharing and analytics (Information visualization and work spaces in Statoil's model)
- **Foundational capabilities layer:** All wells, pipelines, processing plants (taken for granted in the Statoil model)

The intelligent infrastructure (data capture/ standards and communication infrastructure/ standards in Statoil's model)

Step 4: Evaluate and define capability resources and possible sourcing alternatives

Using the example with the two capabilities, well and pipeline optimization and process and market optimization we now clarify the different resources within technology, process, people and governance/organisation elements. In a green field or a new field development the possibilities for creating new configurations of capabilities will be greater that in a brown field where most of the configurations have been stabilised and taken for granted. Each of the elements should be developed in a structure that enables an efficient fit between the operational context, capabilities (resources) and performance. Examples of resources within each resource group:

- **Technology:** Buildings working environments, facilities, plants, pipelines, equipment and systems, automation, IT and communication, software and data_
- **Process:** Business processes - workflow, roles and responsibilities and collaboration
- **People:** Skills, competence, experience, leadership and all other soft people issues
- **Governance:** Organization, positions (decision rights), location of resources, business structure, internal/external sourcing, contracts, agreements, rules and regulations

A key design criterion is to develop the capability resources for efficient operation and efficient scaling. The operational capabilities should be designed to be applicable for a variety of operational contexts. The analytics and collaboration capabilities and the foundational capabilities should also be designed for scaling across different operational contexts. A key issue here is to understand the paradox of change in digital infrastructures (Tilton, et al 2010). In most cases a stable foundation provides flexibility. There will be opposing logics of stability and flexibility operating across layers in the stack. The capability stack has to be stable enough to enrol new resources while at the same time possess flexibility for unbounded growth.

In order to cope with the complexity of the design process, it is important to move back and forth between the template and the definitions of core and foundational capabilities. Often, specific foundational capabilities need not be specified at a high granularity. In order to understand and explore how to best achieve the necessary scalability, they will have to have a more general character, often with a focus on critical functionality and important shared standards. The key is to stop at the right level of description, not get too detailed. The focus should be on the expected performance and how the capabilities are structured to deliver expected value. Figure 5 is an example for the more detailed questions to be asked in Step 4:

We take a core operational capability; well and pipeline optimization and populate it with the various elements from the layers in the stack model, refer to Table 2 (Core operational capability: Well and pipeline optimization).

Step 5. Implementation plan

A key challenge in developing an implementation plan for a green field implementation is the continuous holistic understanding of the effect a given resource has on capability execution and performance. The implementation plan should highlights these impacts and provide a timeline for both execution and oversight.

Executive Challenges

The emerging model that couples ecologies and platforms, creates many challenges for executives. The key challenges associated with generativity are also a part of this challenge. It is not the topic of this Chapter to address these issues in detail but we mention briefly some of the key executive challenges involved in preparation, design and deployment of these capability platforms:

Table 2. Template or table that structures the elements in a stack model examples

Foundational Capabilities			**Analytics and collaboration Capabilities**	**Operational capabilities**
Onshore main -Slug catcher	"Pressure and temperature measurements? Co-mingled/ modelled measurements	Time series of TAG -data stored in historian (PI)	Collaboration tools and logs based on MS SharePoint Process simulator: simulates the performance of the onshore facilities	Roles described in organization/governance model
Subsea -XT -Pipeline	Remotely operated choke, wet gas meter, water fraction meter, sand detector and pressure & temperature transmitters in XT. No measurements in the pipeline Optical/electro-hydraulic multiplexed system. Primary communication is a redundant fibre optic communication bi-directional point-to-point communication link between land and each subsea control module (SCM). The field will be controlled via two 120 km long optical-/electro hydraulic umbilicals from onshore. The primary communication protocol is TCP/IP. Umbilical contain power cables and fibre optic lines	Time series of TAG -data stored in historian (PI)	Interaction of historian data PI via Front-end FAS (Flow assurance system) Pipeline management (PMS) OLGA 2000: Real time simulations of production and slugs, look ahead. Offline model for, what if planning. Mass balance calculation. Liquid hold up management. Online and offline model tuning. MEG monitoring and tracking in all parts of production systems. Hydrate detection and plug location. PMS tracks hydrate risk, hydraulic performance and continuous leak detection capabilities in pipeline.	Roles described in organization/governance model Data management and stewardship Rules of the game for efficient collaboration?
Utilities -Chemical injection -Hydraulic power -Environmental system	PT measurements at XT PT measurements at XT			Roles described in organization/governance model
Gas wells	PT measurements at XT	Time series of TAG -data stored in historian (PI)		Roles described in organization/governance model
Safety -Process shut-down Emerg. shut-down -Safety and automation system				Roles described in organization/governance model

1. Maximize fit between the operational environment/business context and the available resources (people, process, technology and governance/organisation)
2. Focus on the maintaining operational integrity, through:
   a. Transparency, measures, availability
   b. Dynamic risk handling
   c. Dynamic governance, shift in governance structure when necessary due to emerging situations
3. Managing partners and relationships
   a. Relevant Measure and performance
   b. Develop good relations
   c. Clear roles and responsibilities
   d. Dynamic capability development
4. Achieve effective leadership to enhance high performance in the developing business context in the ecosystem in a manner that achieves efficient scaling and sustainability.
5. Design and manage the business elements in the ecosystem with efficient learning and sharing, supporting improvements and innovations.
6. Address and find strategies to live with the paradox of control and flexibility.

CONCLUSION

In this chapter we have stressed the importance of a capability approach for integrated operations and how it can improve our understanding of how people, process, technology and governance issues are connected and managed to create scalable and sustainable practices. We argued that this development of capabilities is happening within an 'ecology' with increasingly virtual, global, and network based/net- centric models of work. This development sees the world from outside-in. We also addressed in what way processes are different from capabilities. By coupling the notion of ecologies and platforms, we are allowing an emerging model of integrated operations that recognizes the critical need of collaboration across traditional boundaries. We have also described the key stacks or elements in such a platform. In practice the technology solutions form the base of the platform with the more people, process and organizational dominant elements making up the top layers of the platform stack. Finally, we ended up with suggestions for how to address developing a capability stack and touched upon some key executive challenges.

REFERENCES

Boudreau, K., & Hagiu, A. (2005). Platform rules: Multi-sided platforms as regulators. In Gawer, A. (Ed.), *Platforms, markets and innovation* (pp. 163–191). London, UK: Edward Elgar.

Cusumano, M. A., & Gawer, A. (2002). The elements of platform leadership. *Sloan Management Review*, *43*(3), 51–58.

Edwards, T., Mydland, Ø., & Henriquez A. (2010). *The art of intelligent energy (iE)- Insights and lessons learnt from the application of iE.* SPE-paper 128669, Presented at Intelligent Energy conference in Utrecht, February.

Edwards, T., Saunders, M., & Moore-Cernoch, K. (2006). *Advanced collaborative environments in BP.* SPE-paper 100113. Presented at SPE-conference Intelligent Energy Amsterdam, April

Gerstner, L. (2002). *Who says elephants can't dance? Inside IBM's historic turnaround.* Harper Collins Publisher. Henderson, J. C., & Kulatilaka, N. (2008). *Principles of capabilities platforms*. Boston University Working paper.

Hepsø, V. (2006). *When are we going to address organizational robustness and collaboration as something else than a residual factor?* SPE-paper 100712. Presented at SPE-conference Intelligent Energy Amsterdam, April.

Hepsø, V., Olsen, H., Joannette, F., & Brych, F. (2010). *Next-steps to a framework for global collaboration to drive business performance.* SPE-paper 126207. Presented at Intelligent Energy Conference in Utrecht, February.

Kogut, B., & Kulatilaka, N. (2001). Capabilities as real options. *Journal Organizational Science*, *12*(6).

Lilleng, T., & Sagatun, S. I. (2010). *Integrated operations methodology and value proposition.* SPE-paper 12576. Presented at Intelligent Energy conference in Utrecht, February

Næsje, P., Skarholt, K., Hepsø, V., & Bye, A. S. (2009). Integrated operations and leadership – How virtual cooperation influences leadership practice. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications* (pp. 821–828). London, UK: Taylor & Francis Group.

Nardi, B. A., & O'Day, V. L. (1999). *Information ecologies: Using technology with heart* (pp. 50–55). Cambridge, MA: MIT Press.

OLF Norwegian Oil Industry Association. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf*. Retrieved September 21, 2009, from http://www.olf.no/getfile.php/zKonvertert/www.olf.no/Rapporter/Dokumenter/051101%20Integrerte%20arbeidsprosesser,%20rapport.pdf

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. S. (2009). Empowering operations and maintenance: Safe operations with the 'one directed team' organizational model at the Kristin asset. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications* (pp. 1407–1414). London, UK: Taylor & Francis Group.

Tilton, D., Lyttinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(5).

Yoo, Y., Hendridsson, O., & Lyytinen, K. (2010). The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(5).

Zittrain, J. (2008). *The future of the Internet*. New Haven, CT: Yale University Press.

KEY TERMS AND DEFINITIONS

ICT: Information and communication technology.

OPC UA: OPC (OLE for process control) UA (unified architecture) is a specification from the OPC Foundation (http://www.opcfoundation.org).

PRODML: (Production Markup Language) is a family of XML and Web Services based upstream oil and natural gas industry standards.

P/T: Pressure and temperature sensor.

Tag: Is here a unique reference point in a technical system, i.e: the location of a PT-sensor.

XML: (Extensible Markup Language) is a set of rules for encoding documents in machine-readable form.

XT: Is an assembly of valves, spools, and fittings used for various types of wells in the oil and gas industry. Stands for Christmas tree because it traditionally had some resemblance with a decorated tree.

ENDNOTE

[1] We are indebted to Tony Edwards that has been a pioneer in using the capability development approach in an oil and gas setting, see Edwards, et al 2006 and Edwards, et. al 2010.

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Section 2
People, Process, Governance, and Technology Capabilities

Chapter 2
How Integrated Operations has Influenced Offshore Leadership Practice

Kari Skarholt
SINTEF, Norway

Lisbeth Hansson
SINTEF, Norway

Gunnar M. Lamvik
SINTEF, Norway

ABSTRACT

This chapter discusses how Integrated Operations (IO) has affected new ways of working and addresses leadership practice in particular. It investigates both the positive and negative effects of IO in terms of virtual leadership teams and local leadership offshore, and how this may affect safety on board. IO contributes to the onshore organization being more actively involved in problem-solving and decision-making in offshore operations compared to earlier. This way, it has become easier to reach a shared situational awareness concerning planning and prioritizing of operations on board. However, the authors find that the integration of sea and land has not been successful in achieving increased hands-on leadership offshore. To explore this issue, they discuss findings from different research projects studying IO and changes in work practices onshore and offshore at different installations/assets in a Norwegian oil and gas company.

INTRODUCTION

Why study leadership practice within an IO context? IO primarily involves *leadership* teams, both offshore and onshore. The introduction of new work practices through the use of advanced communication technology has thus been a concern of management. The offshore crew, for example, is not in the same degree involved in collaboration with the onshore organization, and they do not spend as much time in computer-supported collaboration rooms as the leadership teams do.

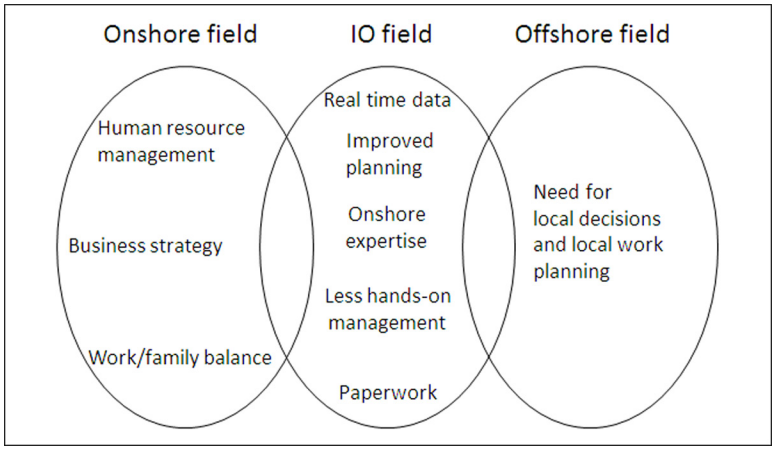
DOI: 10.4018/978-1-4666-2002-5.ch002

Another reason for exploring leadership and IO is that one of the goals for IO has been to develop a more hands-on leadership practice offshore. In the oil and gas company we studied, it was for a while expected that managers spend at least 4 hours outdoors per day during a shift period. The purpose was to encourage a hands-on management practice, which was expected to: Affect offshore workers' attitudes to safe performance, increase awareness in the crew about how to prevent accidents and high-risk situations through the presence of management. Hands-on management is the opposite of doing administrative, electronic paperwork in front of a computer or workstation. To be hands-on means to be involved in "actual" problem-solving and discussions, as well as being out in the process facilities, drill floor, workshops or office-landscape (Næsje et al. 2007). As we have previously argued (Skarholt et al. 2009, Næsje, et al. 2009), being hands-on relates to operating models where one actively seeks to enhance flexibility and robustness, as seen in lean manufacturing or the Toyota production system (Womack 1990).

IO is about improved communication, better work planning and qualified decision-making. In other words, real-time data is made accessible to onshore personnel, and onshore expertise is made available to the offshore organization. A useful concept to illustrate the offshore/onshore axis, as used in Figure 1, is the term social field (Grønhaug 1974). Social field denotes concrete systems of interrelated events. Events in this context are relations between social actors as they pursue their specific tasks, purposes or issues of actions. Empirically, fields can be defined in terms of its own dynamic ("Eigendynamik").

It can be maintained that the offshore/onshore axis consists of three different social fields: The onshore field, the offshore field and, in the middle, the IO field. Each field has a dynamic of its own and interacts with the others. But as we see in Figure 1, there will always be a part of the offshore operation that is not covered by the ICT-based collaboration along the onshore/offshore axis. Some decisions have to be made locally – either in the offshore organization or in the onshore organization. Many incidents or accidents originate in something that takes place solely in one field and thus has to be handled and prevented locally by personnel acting in that particular field. If the overall aim is to pave the way for enhanced hand-on management, and the challenge is seen solely as an offshore issue, then it can be seen as a derailment to communicate the matter to the onshore organization.

Figure 1. The onshore field, IO field, and the offshore field – the limitations of IO



In the so-called IO field, offshore and onshore issues play together. In this field there is a high degree of integration of management and expertise offshore and onshore on the one hand, but on the other, there are still huge obstacles to overcome if one is to achieve visible management or hands-on leadership. In the case of the latter, the primary obstacle is the degree of administrative tasks and paperwork.

The purpose of this chapter is to investigate how IO has influenced leadership practice, with a particular focus on hands-on management, and how leadership practice may have consequences for safety offshore. Safety issues regarding operation and maintenance are the main focus for the offshore managers. In close collaboration with the onshore management team, the offshore leaders are responsible for planning and performing operations and maintenance tasks on board. How to enhance safety on board and prevent accidents and disasters is a main focus for offshore managers. Consequently, a company's HSE philosophy, management style and practice will indeed affect the safety culture on board.

Figure 2 illustrates positive and negative aspects of IO to be discussed in this chapter.

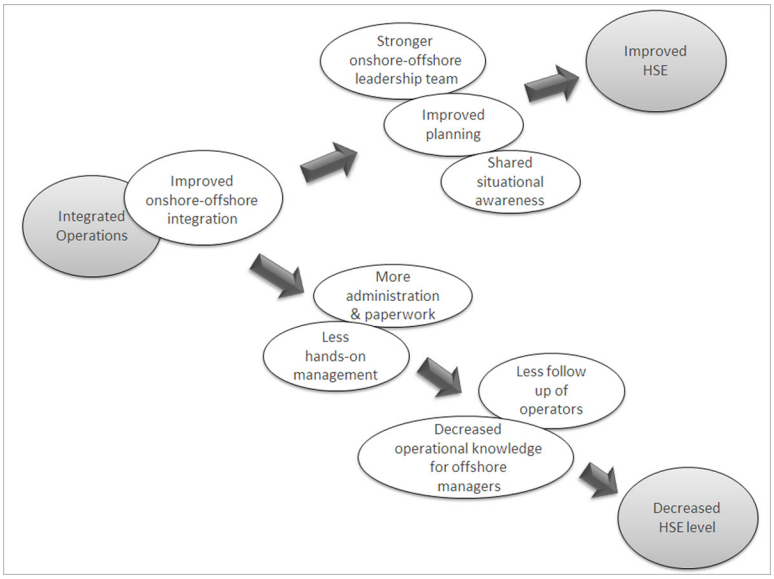
We investigated the dilemma of enhanced integration between the onshore and offshore organization based on findings from our case studies: On the positive side, IO encourages a shared situational awareness between the sea and land organization. On the negative side, IO distances the offshore leaders from the operations offshore, making them less hands-on, because they spend more time in computer-supported operation rooms, meeting and coordination with the onshore organization.

THEORETICAL BACKGROUND

Safety Management

One of the basic assumptions of safety management is that safety should be a management responsibility. For instance, Petersen's (1978) basic principles of safety management are all related to the creation of a management system aiming to control an organization's operational performance.

Figure 2. Positive and negative consequences of IO for HSE



These principles may be paraphrased as follows (Petersen 1978, pp 22-26):

- Unsafe acts, unsafe conditions and accidents are symptoms of failures in the management system
- Circumstances producing severe injuries can be identified, predicted and controlled
- Management should direct safety efforts by setting goals, and by means of planning, organizing and controlling to achieve these goals
- The key to safety is to be found in management procedures that fix accountability
- Safety is about identifying operational errors and designing control mechanisms in order to prevent such errors from (re) occurring.

The field of safety management has certainly evolved since the publication of Peterson's book in 1978. For instance, the emergence of theoretical concepts like safety culture and resilience engineering has in many ways expanded and challenged the scope of safety management (Antonsen et al. 2011). Nevertheless, the *practical* efforts of companies to manage safety still seem to be based on assumptions that human errors are a prime cause of accidents, and, consequently, that controlling employee behavior is a key objective of safety management. (e.g. Krause et al., 1990).

Reviews of safety literature indicate significant associations between leadership and safety outcomes (Guldenmund 2000). Safety performance is closely linked to the leadership role in hands-on operations, proximity to the actual work, and details of work completion during the work day. In complex technological settings, such as the oil and gas industry, it has been investigated how to create robust work practices in an organization (Skjerve 2008; Tinmannsvik 2008). Robust organizations are, among other things, hands-on in operations, and develop supportive learning and flexible work practices.

The concept of safety cultures refers to, "a set of safety-related attitudes, values or assumptions that are shared between the members of an organization (Guldenmund 2000)." Offshore leaders are essential in the development of a good safety culture and in creating commitment to the values. A safety culture may be characterized by harmony and integration or by differentiation and conflict. The goal thus becomes to develop a safety culture that reduces the number of organizational accidents/unwanted incidents. According to Reason (1997), it is important to engineer a reporting culture in which employees are prepared to report their errors and near misses, thereby creating a clear understanding of the difference between acceptable and unacceptable actions. In turn, this will create a learning culture implying safety behaviors among workers and managers (Reason 1997). One characteristic of so-called high-reliability organizations (HRO) is that they are very concerned with and skilled in detecting errors and thus have a proactive and open approach to enhancing reliability (Roberts and Bea 2001).

It is interesting to compare the description of different views about how to perform safety management above – through control and procedures or through developing a learning culture – to the tendencies found in European work life the last 5-10 years. The trend is a change from leadership towards management (Ladegård & Vabo 2010), which means increased control from management through standardized systems and routines. We also see this development in the Norwegian oil and gas industry and in the company we studied. Changes that lead towards management or leadership will affect the company philosophy regarding leadership practice in organizations. The management and organization literature describes a trend, moving from management (control) towards leadership (Byrkjeflot 1997) from the 1980s to the mid-1990s, motivated by a work life in a continuous process of change through digitization of work processes and distributed work. The trend was leadership (empowerment),

and self-managed teams were a part of this development (Sørhaug 2010). However, this trend shifted in the 1990s, and the development went from leadership to management (Røvik 2007). Today, vertical management (top-down) is the trend. This way, we see a link back to Petersen's safety management principles from 1978.

The management and organization literature distinguishes between management and leadership (e.g. Byrkjeflot 1997, Ladegård & Vabo 2010, Yukl 1989, Kotterman 2006). Management is associated with control, whereas leadership implies leading people. Characteristics of management are: planning and budgeting, procedures and routines, and "doing things right". Characteristics of leadership are: motivating and inspiring people through visions and dialogue, teamwork and coaching, and "doing the right things". However, it is difficult to cultivate just management or leadership, because this is a complex role to handle (Ladegård & Vabo 2010). Nevertheless, leadership entails less control (management) and a more hands-on work practice. The company's philosophy of how to lead will be a strong influence on whether you spend time leading people or controlling that procedures and systems are followed.

Leadership, including hands-on leadership, implies having a close and open relationship with the workforce, and can be understood as transformational leadership. According to Bass (1990), transformational leadership means that a leader communicates a vision, which is a reflection of how he or she defines an organization's goals and the values supporting these goals. Transformational leaders know their employees and inspire and motivate them to view the organization's vision as their own (Bass & Avioli 1994). Such leadership occurs when one or more persons engage with others in such a way that leaders and followers lift each other to higher levels of motivation. In terms of safety and leadership, the ability of leaders to develop a good safety culture will depend on how values and norms are communicated and shared among the members of an organization. To be hands-on as a leader will make visions and values more visible in the organization and thus easier to follow by the members.

Shared Situational Awareness

The term shared situational awareness refers to how teams communicate and solve problems together. In virtual teams, such as in integrated operations, a shared situational awareness develops through close collaboration between the onshore and offshore organization, thus enabling improved problem-solving and decision-making (Skarholt et al. 2009; Næsje et al. 2009).

According to Olson & Olson (2000), establishing a "common ground" is essential in the effort to collaborate across geographical distances. They describe which elements are crucial for success in virtual teamwork, such as the sharing of knowledge, coupling in work, the need for collaboration to solve tasks, and the need for technology that effectively supports communication and decision-making. A common ground or shared situational awareness is an important premise for good decisions. Rosseau et al. (2004), Artman (2000), and Patrick and James (2004) argue that teamwork, or working towards a shared goal, requires information sharing and coordination. Shared situational awareness represents the overlap between team members, or the degree to which team members possess the same situational awareness or shared mental models.

Situational awareness can be divided into three levels (Endsley 1995): (1) perception, (2) understanding and (3) prediction. Perception is to register information from the environment, understanding is about interpreting the situation based on experience and knowledge, and prediction means to imagine how the situation will develop. A shared situational awareness implies being aware of the knowledge and responsibilities of others and how this affects your own work. In a crisis situation, it is crucial that a team is able to mobilize and improvise. The ability of team

members to create a shared situational awareness will influence how they solve a crisis situation (Rosness & Sætre 2008). The result depends on the personnel involved and the knowledge they possess.

According to Artman (2000), we must focus on three issues in order to understand how a shared situational awareness develops. First, one must go beyond the individual members and include whole teams, or the concerted efforts of several team members and their actions. Second, one must consider that cooperative work is based on the existence of mutually shared and interdependent goals between team members, and, finally, team situation awareness relies on the use of various artifacts and presenting information to the team. Various team members can have different information resources that must be combined and coordinated to develop a shared understanding.

Shared understanding has a significant impact on the ability of teams to coordinate their work and perform well; it affects performance in several ways, such as predicting the behaviours of team members, increasing satisfaction and motivation, and taking actions that benefit the team and the outcomes (Hinds & Weisband, 2003). In the absence of shared understanding, frustrations, conflicts and distrust can develop.

Trust in Virtual Teams

IO is about how members of a geographically distributed organization participate, communicate and coordinate their work through advanced information technology. Skarholt and Torvatn (2010) explored the role of trust within integrated operations, and found that trustful relations between onshore and offshore personnel contributed to creating a better safety culture on board. The development of distrust between sea and land may lead to fatal safety consequences. When communicating across geographical distances, information-sharing, problem-solving, and decision-making become more difficult and demanding compared to face-to-face relationships (Lipnack and Stamps 1997). And virtual collaboration is especially challenging with regard to the development of trust. Therefore, a collaborative relationship built on mutual trust will strengthen and affect the decision-making processes in a positive way. According to Baan and Maznevski (2008), trust is the glue that holds virtual teams together.

Trust has been studied in different ways to address a wide range of organizational questions, focusing on the effects of trust and distrust (Kramer & Tyler 1996, 2004, Verkerk 2004, Lewicki & Bunker 1995, Gambetta 1988). The dominant approach emphasizes the direct effect trust has on important organizational phenomena, such as communication, conflict management, negotiation processes, satisfaction and performance. From a mobilizing perspective, trust motivates actors to contribute, combine and coordinate resources toward collective efforts. Specifically, trust influences the processes of knowledge sharing, commitment and identification (McEvily, Perrone and Zaheer 2003).

What is trust? At a general level, trust is the willingness to accept vulnerability based on positive expectations about another's intentions or behaviors (Meyer et al. 1995; Rousseau et al. 1998). The definition demonstrates that trust is characteristic of a social relation, and has to do with the positive expectations individuals have of other people's intentions or behaviors in situations where there is a risk of loss, injury, or the infliction of other inconveniences.

Giddens (1994) emphasizes the significance of trust as an active process that modern people increasingly have to actively nurture to maintain. The concept of active trust describes this as a process that requires action and engagement. In a society or organization that continuously changes, or no longer can be taken for granted, such as the oil and gas industry, trust becomes more of a personal matter. Trust is thus not something that can be taken for granted, but is something that is developed through repeated interaction. According to Zand (1997), successful early contact is

the key for trust to develop into a self-reinforcing spiral. Such a development involves a gradually increased openness in a relationship, where one party eventually gives the other party access to more information and cuts back on controlling measures. A reflexive understanding of trust takes an active approach to trust with interaction-based initiatives directed toward other people. Trust as a dynamic process is linked to the development of social relations.

CASE DESCRIPTION

Today, several oil and gas companies on the Norwegian continental shelf (NCS) have, through advanced information and communication technology, introduced new forms of collaboration and information sharing. The development of IO at several installations on the NCS is claimed to be a potential for increased profit, increased production and exploitation of fields and reserves, as well as improved safety (OLF 2003; 2006). There are a variety of concepts describing IO, also called Intelligent Energy and e-Operations. IO allows for a tighter integration of offshore and onshore personnel, operator companies, and service companies, by working with real-time data from the offshore installations.

We find that these are the most typical IO-driven changes on the NCS (e.g. Skarholt et al. 2009, Næsje et al. 2009, Hepsø et al. 2009, Edwards et al. 2010):

- A move to real-time or near real-time way of working
- Increased onshore support (planning, expertise, competence centers, management)
- Virtual teams working in computer-supported collaboration rooms: a common arena for leaders, planners, HSE personnel and discipline experts. Enables information sharing, rapid responses and shared decision-making.
- Production optimization as a potential for enhanced and reliable production. This involves multidisciplinary collaboration between the onshore and offshore organizations, as well as increased coordination compared to earlier.

To explore how IO has affected leadership practice, we present and discuss findings from different research projects conducted in a Norwegian oil and gas company. We have studied change in work practices related to IO at several installations operating on the NCS, all of them owned and operated by this company. In 2009, the company implemented a common and standardized operation model for all their offshore installations the NCS, which was described as a full scale implementation of IO. The goal, among others, was to increase the time spent out on the installation – both related to the managers' and the crews' work practice. For the managers, the new model was designed to move planning and administration onshore, which in turn would give the offshore managers time to become more hands-on in terms of operations. Also, crew members were expected to increase the time spent outdoors, thus reducing the time spent on administration tasks.

The empirical data for our study comes from three research projects, and all of them were conducted in a major oil and gas company in Norway. The data was collected from 2006 to 2011 and consists of both qualitative data (in-depth interviews and participant observation) and quantitative data (web-based surveys).

In 2006, we studied the work situation of offshore managers in light of the oil company's goal of increasing the time spent outdoors (hands-on management), in contrast to the office-based paperwork that was occupying more and more of their working periods on board. The findings from this study are based on a web-based survey covering 187 offshore managers from nine installations on the NCS.

In 2007, we studied IO work practices at one particular asset/installation in this oil company. This was the first installation at on the NCS that was actually designed for integrated operations already in the design phase. It is a small and modern installation that developed new work practices and collaboration arenas both on board and in interactions between land and sea. A total of 69 interviews were conducted with the onshore organization (planners, engineers, managers) and the offshore organization (management teams and crew, covering all disciplines and all three shifts). In addition, participant observation was conducted in computer-supported collaboration rooms both onshore and offshore, and in the process plant offshore, studying the work of the crew.

In 2007-2011, we conducted a research project studying the effect of IO in terms of leadership practice offshore (hands-on management vs. paperwork) and how new IO work practices could affect the safety on board, both positively and negatively. Also, the implementation of a common and standardized operation model with enhanced cooperation between sea and land was studied in this project. Three offshore installations in the oil company studied took part in this study, and we conducted both in-depth interviews (50 interviews in 2009 and 52 interviews in 2010) and web-based surveys (2009 and 2010). In these surveys, we compared the findings from the 2006 study described above: Has the time spent outdoors increased or not among offshore managers? And how has IO affected the practice of hands-on management offshore?

RESULTS AND DISCUSSION

The discussion focuses on the following dilemma: IO contributes to improved integration between the onshore and offshore organizations, which is positive in terms of planning and executing critical operations and maintenance tasks on board, while on the other side increased coordination with the onshore organization is time consuming and hamper hands-on management on board. We explore: 1) Shared situational awareness among onshore and offshore leadership teams; 2) The importance of trust in onshore-offshore virtual leadership teams; 3) Challenges concerning hands-on management offshore; and 4) How IO may affect HSE.

IO Creates Shared Situational Awareness among Onshore–Offshore Leadership Teams

We found that IO contributes to more active involvement from shore in problem-solving and decision-making concerning offshore operations compared to earlier. It has become easier to reach a shared situational awareness concerning planning and prioritizing of operations on board. This is obviously a positive consequence of IO. It is now easier to gain a common understanding because of more frequent contact and a feeling of "being in the same room" through the use of collaboration rooms. Many of the interviewees express that the onshore organization has become closer to the offshore organization after implementing IO. In addition, more planning activities and responsibilities are moved onshore, which influences this relation.

In the 2007 study, we focused on how IO affected work practices, and virtual collaboration through video conference collaboration rooms was a part of this study (Skarholt et al. 2009). We found that daily informal contact and formal meetings in collaboration rooms created a situation of shared situational awareness between the management teams onshore and offshore.

The collaboration room enables access to important information, where we get to know about each others tasks and an overall impression of the work onshore and offshore. Thus, we perform the work as one management team, and not only as individuals. (Manager)

At the installation where we studied IO work practices in 2007, there are two management teams, one onshore and one offshore, each located in a collaboration room. The collaboration is supported by the use of video conferencing and data sharing facilities, where both management teams can see each other at all times during the workday. Also, process data is online and available at both locations and can be shared. Both the offshore and the onshore management uses the collaboration room on a permanent basis, as their office, and not as a meeting room like several other assets on the NCS do. The contextual differences (different work atmospheres, weather conditions, etc.) offshore and onshore become less important by the use of collaboration rooms. In the onshore collaboration room there are several video walls showing pictures/video of the platform, the technical equipment, and the people working there.

The onshore management team is responsible for providing day-to-day operational support to the offshore organization, and for the planning maintenance programs and tasks on a long-term basis. This takes place through formal daily meetings and through informal and ad hoc dialogue during the day. In addition, the managers meet in person in informal and formal meetings onshore quite often, which strengthens the quality of the virtual work. The random personal contact and the fact that people know each other make the distance leadership closer (Maznevski & Chudoba, 2000). This is an important criterion for success in virtual cooperation. We found that close collaboration across management teams onshore and offshore has lead to more effective problem-solving and decision-making processes. One indication was the low number of backlog activities concerning operations, maintenance, and HSE work.

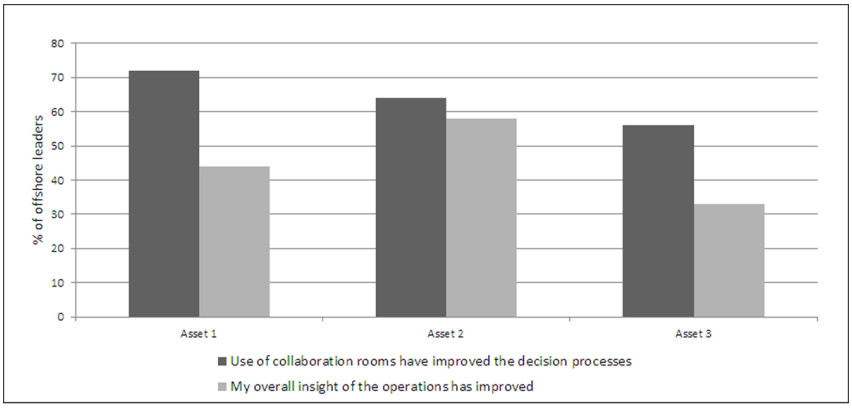
The platform management expressed that their aim is to behave as one management team, meaning that they want to coordinate problem-solving and decision-making between shifts. Once a week, even in their time off, the platform managers arrange a telephone meeting to discuss and share opinions concerning operation plans and their execution. This way, they develop hands-on knowledge regarding what's going on at the platform, where tasks are being followed up on and rapidly solved. The managers expressed that the aim is consistent leadership behaviours and to obtain coordinated management solutions across shifts. Nevertheless, it is challenging to coordinate technical activities across different shift periods. For example, there have been situations where decisions made by management are not coordinated between shifts. However, these have not been critical decisions.

The enhanced onshore-offshore collaboration is supported by the survey results from 2010, as indicated in Figure 3. The graph presents the response from offshore leaders at three different assets/installations. For all three, the leaders indicated that the collaboration rooms, and thus also the video-conferencing facilities, have improved the decision-making processes. They also indicated that their overall insight has improved following the implementation of IO. There are several reasons why the responses from leaders are more diverse on the latter statement; the installation's size and the history (organizational design and philosophy) of the asset are two of the contextual aspects influencing the results. On the smaller assets, such as asset 3, the onshore-offshore collaboration may have been rather good even before introducing IO.

The Importance of Trust in Virtual Leadership Teams

We found that trusting relations between the onshore and offshore organizations have a positive impact on safety conditions. The climate/culture of how individuals and groups in the organization communicate and collaborate will affect how situations involving safety are handled. Most literature reviews conclude that the concept of safety cultures refers to a set of safety-related attitudes, values or assumptions that are shared between

Figure 3. Enhanced onshore-offshore collaboration with IO (survey 2010)



the members of an organization (Guldenmund 2000). A safety culture may be characterized by harmony and integration or by differentiation and conflict – or by trust or distrust. On a general level, a geographically distributed organization, as that found in the oil industry, faces several safety challenges due to cultural differences. For example, the relationships in the onshore and offshore cultures (company cultures) in the North Sea have long been described as an "us and them" dichotomy. Traditionally, the situation was characterized by very little collaboration and a lack of a shared understanding between the onshore and offshore personnel. Thus, a situation of distrust developed between the onshore and offshore organizational groups. Distrust can create situations where ideas, information and input from "the other" group may be ignored, and safety might thus be compromised. Nevertheless, in the last few years we have found that the communication and collaboration between the onshore and offshore organizations has improved. The stereotypical and negative opinions of each other have diminished. Increased integration and involvement from the onshore organization through the implementation of integrated operations has affected this relationship in a positive way.

According to Baan and Maznevski (2008), trust is the glue that holds virtual teams together. Below are two examples of how trust plays an important role in improving the communication and collaboration between sea and land. First, in 2009 the company in our case study decided to rotate senior personnel between the onshore and offshore organization in an effort to increase integration and to strengthen the operation and maintenance competence onshore. This was one of the goals for implementing a common and standardized operation model at all of their installations on the NCS. This involved a rotation of senior offshore workers within all disciplines: electro, mechanic, process and automation. We found that this rotation practice was very successful in terms of bringing more offshore expertise to the land organization. The rotation implies working one year onshore performing planning activities within operation and maintenance, and then working two years offshore performing operations and maintenance tasks on the installation. This way, the offshore personnel in rotation gets to know the personnel and the tasks onshore thoroughly – and vice versa. Stronger trust relations between sea and land have thus developed through closer relationships and improved onshore support. Offshore workers rotating between land and sea also contributed to the personnel offshore more strongly trusting the plans and decisions made onshore, because they know they are based on in-depth insight and understanding of the installation. Local knowledge about the installation is difficult for the onshore

personnel to acquire (some of them have never been offshore) and this is why it is important to integrate the experience and competence of offshore workers in the onshore organization.

We are completely dependent on high operational competence onshore – the senior offshore workers in land rotation are extremely important. (Offshore worker)

The other example is about the problems of obtaining trust in virtual collaborations if you never have met face-to-face before: As a part of the virtual onshore-offshore collaboration there is a support division onshore with engineering competence from all disciplines necessary to run the offshore operations. Their role as engineers is to assist both the onshore and onshore leadership teams. We found that this support worked very well for some of the assets, but rather poorly for others. For some of the assets, the onshore leadership team and the support division are colocated, but this is not the case for all assets. The geographically colocated assets have face-to-face contact and find that they know each other quite well. This situation contributes to creating trust relations. However, trust building is more demanding for those assets that are not colocated.

No one in the support division knows our asset very well. This makes it more difficult to understand our needs in terms of support. (Manager)

We found that it is easier to get the necessary support and to build trust relations when people actually have met before. The lack of support from the expert division did in some situations lead to distrust between the experts and the onshore leadership team. The reason was that it is difficult to trust people you have never met, and this contributed to greater dissatisfaction regarding the support received. Before, the leadership team in this asset had the specialist expertise in-house and this way they could solve problems together more efficiently.

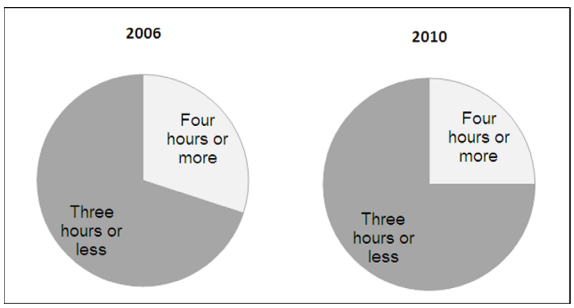
Challenges Concerning Hands-on Management Offshore

One of the intentions of implementing IO and a standardized operation model offshore in the company we studied was to increase the time spent *out* on the installations, both for offshore managers and crews. Planning and administration was moved from sea to land, which in turn should give offshore managers the time to become more hands-on in operations. In addition, it was for a while expected that managers spend at least 4 hours a day outdoors during a shift period.

Figure 4 shows results from the surveys conducted in 2006 and 2010. The offshore managers were asked how many hours per shift they spent out in the field performing hands-on management. As indicated in the graph, they spent less time out in 2010 than they did in 2006, even if one of the intentions of IO and the new operation model was to enhance hands-on management. 70 percent of the offshore managers claimed that they spent three hours or less out in the field in 2009, and in 2010, this number had increased to 75 percent.

The centralized planning onshore, which was intended to reduce the time spent on administration offshore, actually seems to have *increased* the need for administration. This is probably related to the split between the planning and execution of operations in the company's new operation model, which seem to increase the need for communication and coordination between offshore operators and the onshore organization. It should

Figure 4. Time spent out in the field, 2006 and 2010



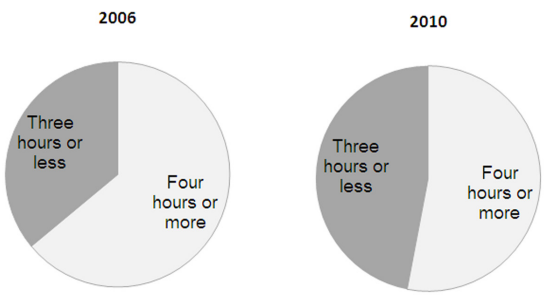
be noted that this is not necessarily a bad thing. However, it does not seem to have contributed to the goal of reducing the number of administrative tasks offshore and increasing the time spent outdoors. IO has meant a lot of changes and challenges for the onshore organizations as well, not only offshore. At the assets we studied, it seems that the onshore organizations had not been upgraded (manning, expertise) to handle all the new administrative tasks. In addition, we found that some of the tasks previously performed offshore were more difficult to solve onshore, such as shift plans for offshore personnel and following up on sick leaves. These tasks are more efficiently handled by the offshore organization.

Another challenge in the effort to increase hands-on leadership offshore is the improved integration between sea and land. We found that offshore leaders find it very challenging to spend "enough" time outdoors with the crew. Today, the offshore leader team has more contact with land than before, through both formal and informal meetings during a day. Coordinating activities and decisions with the onshore organization is very time-consuming and may thus "steal" attention from being close to the crew and the operations on board. In addition, IO entails a much broader participation from the personnel both onshore and offshore, and this implies more meetings and coordination concerning decision-making, where management is usually involved.

The implementation of a common and standardized operation model on all the offshore installations owned by the company studied is also affecting the leadership practices and philosophy offshore. This model has increased management control of offshore operations, by moving planning and decision-making onshore. We found that the leadership philosophy in the company has changed from leadership to management, which mirrors the trend in European work life over the last 5-10 years. This means a move from transformational leadership practices with close relationships between an empowered crew and an offshore leadership team towards a management practice that involves increased control from the management teams both offshore and onshore. However, a development towards more control from the offshore managers has not increased the time they spend outdoors being hands-on the operations. The managers are hands-on in terms of following up on plans, work procedures and systems offshore, but not hands-on in terms of actually being outdoors with the crew.

This general change from leadership to management, as we have discussed earlier, may be one of the explanations for the figures presented in the Figure 5. This graph shows how much time the responding offshore leaders would like to spend out in operation. Even if the offshore managers would like to spend significantly more time outdoors than they actually do, this number has decreased from 2006 to 2010. Another explanation for this decreasing interest in spending time out in the field may be related t the background of the offshore leaders. Traditionally, offshore leaders had a practical background, whereas today, the trend is to recruit leaders with an academic background. A leader with a practical background may be much more confident when attending the operational life outdoors and they may actually assist the operators with practical problem-solving. Academic leaders may not have expertise to assist on practical issues and this may reduce their au-

Figure 5. Desired time to be spent out in the field, 2006 and 2010



thority. Still, more than 50 percent of the offshore leaders would like to spend four or more hours out in the field, while only around 25 percent respond that they do spend this much time out.

As previously described, the leadership team offshore spend a lot of time in a computer-supported collaboration room, where they are in frequent contact with the leadership team onshore. Using the collaboration room on board as the management's regular office encourages communication and collaboration among the management on board:

One important aspect with IO at this installation is the informal communication that happens 16 hours a day. In the operation room I receive a lot of useful information from the other managers who are sharing this room with me. (Manager)

A close collaboration within the offshore leadership team is positive when it comes to building a strong team. However, the challenging aspect with the use of collaboration rooms is that it can impede the managers' hands-on relationships with people outside this room, such as the relations with the offshore workers/crew. We found that the crews want to have the managers be more available, which means they would like managers to be more present out in the process plant:

The leaders are often in meetings during a workday. They spend much of their time in the glass cage [collaboration room]. (Offshore worker)

We don't experience that the leaders spend much time out in the production area. There are more meetings now compared to earlier. (Offshore worker)

The leaders shouldn't be outdoors doing the same job as us, but we appreciate that they are out in the production area and thus are hands-on with our job activities. (Offshore worker)

As the quotes above indicate, the crews on board find that the management teams spends most of their time in the collaboration room and that there are a lot of meetings and coordination with the onshore organization during a typical workday. They express that their leaders being present is not crucial for the performance of their work out in the production plant. Nevertheless, they want the leaders to be more hands-on. Being hands-on for them means that they want the leaders to care about them and their work; they want to be seen. They are not saying that their leaders do not care about them, but they want more of this.

One of the technical engineers put it this way: *"*For some of us, the collaboration room becomes like a drug.*"* What he means is that you become dependent of the information and the conversations you are part of in the collaboration room. This explains why attending the collaboration room is useful for the managers. Nevertheless, some of the managers offshore express that they spend a lot of time outdoors together with the crew, and we found that some leaders prioritize this more than others and thus the time spent outdoors varies between shifts. But still, the offshore workers want the leaders to be more hands-on.

Figure 6, which presents results from the surveys in 2006 and 2010, indicates the main activities preventing the offshore leaders from being out in the field. Reading and responding to e-mail is a constant "time-thief", and is at approximately the same level in 2006 and 2010. After the survey in 2006, the researchers commented that it was an unexpected finding that e-mails are the single most important source of interruption and barrier to outdoor work (Lamvik et al. 2008). Managers describe e-mails as a tool for communication, which is often misused. It is too easy to distribute (unnecessary) information to a large number of colleagues, the CC function is used too often, and it is far too common to use the e-mail system as a channel for discussion and decision-making rather than strictly for communication purposes. Many offshore managers find writing and responding to

e-mails to be a considerable challenge. It could be anticipated that the increasing use of video conferencing would reduce the massive use of e-mails, but the survey from 2010 does not give any indication of this.

The time spent on video conferencing or telephone conferencing with the onshore organization has, not surprisingly, increased drastically from 2006 to 2010. Meetings onboard and administrative tasks are other activities stealing the managers' time. Administrative tasks were one of the activities planned to be moved to the onshore organization as a part of the IO implementation, but this is still a main activity for offshore leaders.

In the survey, more than 90 percent of offshore leaders agreed that the following reasons for spending time out in the field is important. There were no essential differences to the responses between 2006, 2009 and 2010.

- Prevent dangerous situations
- Influence on HSE
- Being a visible leader
- Maintain own competence (operational)
- Learn more about operations

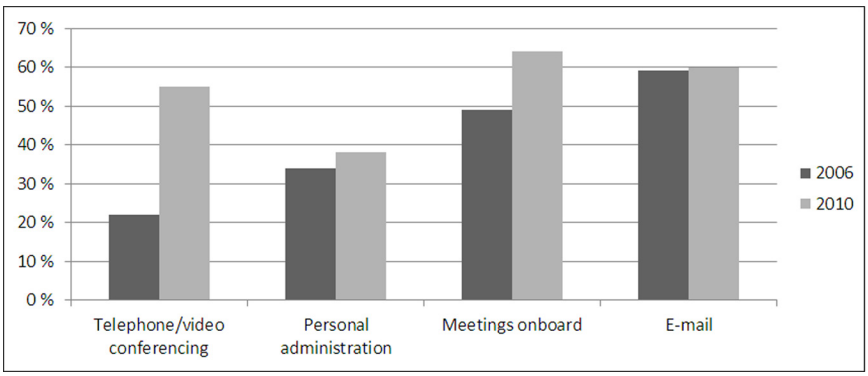
As described earlier, the company's goal for hands-on management was to affect offshore workers´ attitudes to safe performance, to increase awareness in the crews about how to prevent accidents and to prevent high-risk situations. The survey showed that the focus on safety on board and how to prevent dangerous situations was a main concern for the leaders. In addition, they wanted to be visible among their crew members. This is in accordance with the crews' own expectations; they wanted a more hands-on leadership practice as described earlier. Also, the leaders wanted to spend time out in the field in an effort to maintain their operational competence. There may be safety problems if the offshore leaders lose their ability to follow up on the operational tasks carried out by the crew. This may very well be the consequence if offshore leaders reduce the time spent outdoors.

How IO Affects the HSE Level of the Offshore Installation

In this chapter we have discussed the improved integration between the onshore and offshore leadership teams and the reduction in available time for hand-on management. Towards the end of this chapter we suggest the effects these IO-related changes will have on HSE.

Health, Safety and Environment (HSE) is a diverse and complex concept. "Safety" covers occupational accidents as well as major accidents, and "environment" covers both the external environment, such as pollution, and the working

Figure 6. Activities preventing offshore leaders from being out in the field



environment. In this context, we mainly focus on safety (occupational as well as major accidents) and working environment. Occupational accidents are personal injuries, such as falls, dropped objects and pinching incidents. The consequences can be severe, but these situations never develop into catastrophic events. Major accidents cover events such as fire, explosions, large gas leaks and blowouts. It is clear that of the aspects we discussed concerning the implementation of IO, some will affect the probability of occupational accidents, some will affect the probability for major accidents and others will affect the working environment.

The underlying causes of occupational accidents and major accidents are diverse, even if a relation between them has traditionally been anticipated. This is often referred to as the iceberg theory, first described by Heinrich (1931), and has been widely used in safety related work in the oil and gas industry. The main idea behind this theory is that there is an important link between occupational accidents and major accidents. By controlling the less severe personal injuries it was believed that the likelihood of major accident was also under control. The reporting and statistics for personal injuries or occupational accidents, called H-values, were used as an indicator for the general safety level. Lately, however, safety experts have more or less abandoned the iceberg theory, realizing that these relationships are not that obvious, and indicators for major accidents are now more widely used to prevent accidents and reduce risk (Hovden 2004).

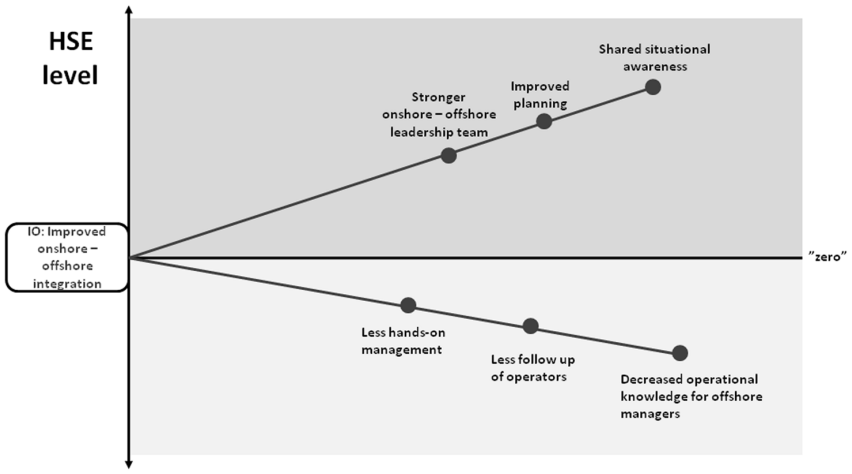
The division between occupational accidents and major accidents is important for the discussion and conclusions in this chapter as well. It is obvious that some of the IO implementation aspects we have discussed will have implications on the probability for major accidents, while others will have implications on the risk of occupational accidents or working environment. Some aspects can affect all three.

The negative and positive HSE effects from IO related changes are summarized in Figure 7. In this graph, positive effects are indicated by the solid line above the "zero level" and negative effects are indicated by the solid line below the "zero level". On the positive side, we find the success of the virtual onshore-offshore leadership team, the improved planning process and shared situational awareness. On the negative side, offshore leaders tend to have less time for hands-on management. The effect is less time spent out in the field to follow up on operations and a decreased operational understanding and competence among offshore leaders.

Starting with the positive effects of IO, a stronger onshore-offshore leadership team, shared situational awareness and improved planning of maintenance, it can be argued that this will have a positive effect on the likelihood of major accidents. Improved planning in this context mainly refers to prioritizing safety critical maintenance activities. More long-term planning gives the team of offshore and onshore leaders a better overview and they seem to have a better and shared situational awareness on an overall level. Plans and priorities made by the onshore group may be built on a more overall insight compared to the priorities made locally on the installation. Shared situational awareness enables improved problem-solving and decision-making. As we have discussed, shared situational awareness can be divided into perception, understanding and prediction. Perception is to register information from the environment, understanding is about interpreting the situation based on experience and knowledge, and prediction means to imagine how the situation will develop. In crisis situations it is crucial that a team is able to mobilize and improvise. The team members' ability to create a shared situational awareness will influence how they solve a crises situation.

Also, IO entails broad participation from discipline experts and contractors, among others, that influence problem-solving related to offshore

Figure 7. HSE effects of IO



operations. In collaboration rooms, many different actors from different organizations see and have access to the same information, thus having a potential for strengthening the safety work. In general, IO has a proactive focus, strengthening the ability to discover and be prepared for unexpected situations by the use of real-time data, integrated planning and more actors creating a shared situational awareness. More people can be trained to handle complex situations, by "on the job training" as well as by more realistic simulation and training. The capacity for organizational redundancy is improved as more actors can observe, participate and contribute across boundaries between disciplines and organizations (Rosness 2002). This contributes to develop a more robust organization. Multidisciplinary teams and different situational awareness can be an arena for creation and maintenance of both cultural and structural redundancy. However, it might be difficult to establish organizational redundancy across geographical distances. It can also be challenging to establish organizational redundancy across boundaries between different actors with different interests, particularly as teams are brought together when a situation requires them to. Complex structures of authorities across cultural and geographical borders can create challenges in terms of responsibilities in crisis situations.

As regards the negative HSE effects, these may be more complex. The trend towards less hands-on management on the offshore installation can affect the working environment, the risk for occupational accidents and likelihood of major accidents. The manager being out in the field gives the operational crew a feeling of being appreciated, which influences the working environment. We have described how the offshore leaders can affect the safety culture on board, but this requires proximity to the operators and the operations. Safety performance is closely linked to the leadership role in hands-on operations, proximity to the actual work, and details of work completion during the workday. Offshore leaders are role models when it comes to the use of personal safety protective equipment, such as helmets and gloves, and the use of these reduces the risk of personal injuries or the consequence of an injury. Offshore leaders also tend to focus on work practices when they are out watching operations, and as there are and shall be several barriers protecting against major accidents, improper performance will primarily

affect the risk of occupational accidents. The fact that less hands-on management also reduces the manager's overview of operational details may also affect the risk of major accidents. In critical situations, in particular, managers must make decisions in a very short time, and the ability to improvise is crucial. Local knowledge combined with a good overall insight can be a key success factor to making the right decisions in a critical situation.

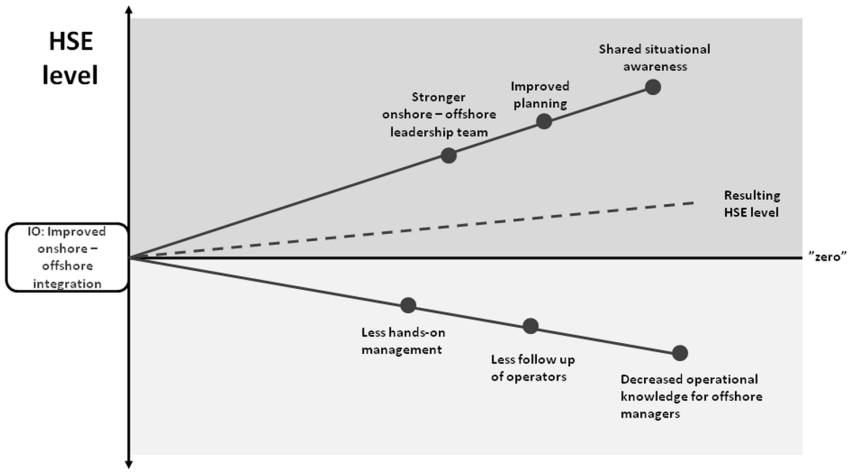
CONCLUSION

In this chapter we have discussed how Integrated Operations has influenced offshore leadership practice. The intention of increasing hands-on management has instead been replaced by inclusion in the virtual onshore-offshore leadership team. Insight into offshore life and close contact with daily operations on the installation has in part been replaced by a more overall situational awareness for the offshore leaders. How this change in offshore leadership practice will influence the overall HSE level is not easy to predict, but we have given some thoughts on the direction this might take, indicated in Figure 8.

The main concern with IO and increased integration between onshore and offshore is whether the overall positive HSE effects overshadow the negative HSE effects. In this graph, the positive effects are indicated by the solid line above the "zero level", the negative effects are indicated by the solid line below the "zero level", and the resulting overall effect on the HSE level is indicated by the dotted line. Obviously, the dotted line should be as far above the "zero level" as possible. If the resulting HSE level is above the "zero" level, the implementation of IO can be regarded as a success in terms of HSE.

The positive and negative effects may, however, not be comparable, as they may "belong to" different aspects of HSE. Increased cooperation and improved situational awareness may decrease the probability of major accidents, while less hands-on management may increase the likelihood of personal injuries and worsen the work environment.

Figure 8. Indication of resulting HSE level after implementation of IO



REFERENCES

Antonsen, S., Skarholt, K., & Ringstad, A. J. (2011). (in press). The role of standardization in safety management. *Safety Science*, (Special Issue). doi:10.1016/j.ssci.2011.11.001

Artman, H. (2000). Team situation assessment and information distribution. *Ergonomics*, *43*, 1111–1128. doi:10.1080/00140130050084905

Baan, A., & Maznevski, M. (2008). Training for virtual collaboration: Beyond technology competences. In Nemiro, J., Beyerlein, M. M., Bradley, L., & Beyerlein, S. (Eds.), *The handbook of high performance virtual teams: A toolkit for collaborating across boundaries*. San Francisco, CA: Jossey-Bass.

Bass, B. M., & Avioli, B. J. (1994). *Improving organizational effectiveness through transformational leadership*. Thousand Oaks, CA: Sage.

Byrkjeflot, H. (Ed.). (1997). *Fra styring til ledelse (From management (control) to leadership)*. Bergen, Norway: Fagbokforlaget.

Edwards, T., Mydland, Ø., & Adolfo, H. (2010). *The art of intelligent energy (iE) – Insights and lessons learned from the application of iE*. SPE 128669.

Gambetta, D. (1988). *Trust: Making and breaking cooperative relations*. New York, NY: Basil Blackwell.

Giddens, A. (1994). Risk, trust, reflexitivity. In Beck, U., Giddens, A., & Lash, S. (Eds.), *Reflexive modernization*. Cambridge, UK: Polity Press.

Guldenmund, F. W. (2000). The nature of safety culture: A review of theory and research. *Safety Science*, *34*, 215–257. doi:10.1016/S0925-7535(00)00014-X

Heinrich, H. W. (1931). *Industrial accident prevention*. New York, NY: McGraw-Hill.

Hepsø, V., Munkvold, G., Rolland, K., & Olsen, H. H. (2009). Ny praksis produksjonsoptimalisering muliggjort av integrert operasjon. Spredningen av detaljert produksjonsoptimalisering (DPO). In Hepsø, I. L., & Kongsvik, T. (Eds.), *Forskning som endringsverktøy i organisasjoner*. Trondheim, Norway: Tapir.

Hovden, J. (2004). *Sikkerhet i forskning og praksis: Et utfordrende mangfold med Sikkerhetsdagene som arena. Fra flis i fingeren til ragnarok* (p. 44). Trondheim, Norway: Tapir Akademiske Forlag.

Kotterman, J. (2006). Leadership versus management – What is the difference? *Journal for Quality and Participation*, *29*(2), 13–17.

Kramer, R. M., & Tyler, T. R. (1996). *Trust in organizations: Frontiers of theory and research*. Thousand Oaks, CA: Sage.

Krause, T. R., Hidley, J. H., & Hodson, S. J. (1990). *The behavior-based safety process: Managing involvement for an injury-free culture*. New York, NY: Van Nostrand Reinhold.

Ladegård, G., & Vabo, S. I. (Eds.). (2010). *Ledelse og styring*. Oslo, Norway: Fagbokforlaget.

Lamvik, G., Næsje, P. C., Skarholt, K., & Torvatn, H. (2009). Paperwork, management and safety: Towards a bureaucratization of working life and a lack of hands-on supervision. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory methods and applications*. London, UK: Taylor & Francis Group.

Lewicki, R., & Bunker, B. B. (1995). Developing and maintaining trust in work relationships. In Kramer, R. M., & Tyler, T. R. (Eds.), *Trust in organizations: Frontiers of theory and research*. Thousand Oaks, CA: Sage. doi:10.4135/9781452243610.n7

Lipnack, J., & Stamps, J. (1997). *Virtual teams – Reaching across space, time, and organizations with technology*. New York, NY: John Wiley & Sons, Inc.

Maznevski, M. L., & Chudoba, K. M. (2000). Bridging space over time: Global virtual team dynamics and effectiveness. *Organization Science*, *11*(5), 473–492. doi:10.1287/orsc.11.5.473.15200

McEvily, B., Perrone, V., & Zaheer, A. (2003). Trust as an organizing principle. *Organization Science*, *14*(1), 99–103. doi:10.1287/orsc.14.1.91.12814

Næsje, P., Skarholt, K., Hepsø, V., & Bye, A. (2009). Empowering operation and maintenance: Safe operations with the "one directed team" organization model. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory methods and applications* (*Vol. 2*, pp. 1407–1421). London, UK: Taylor & Francis Group.

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction*, *15*, 139–178. doi:10.1207/S15327051HCI1523_4

Reason, J. (1997). *Managing the risks of organizational accidents*. Aldershot, UK: Ashgate.

Roberts, K. H., & Bea, R. (2001). Must accidents happen? Lessons from high-reliability organizations. *The Academy of Management Executive*, *15*(3).

Andresen, G., Rosness, R., & Sætre, P. O. (2008). Improvisasjon - tabu og nødvendighet (Improvisation – tabu and necessity). In R. Tinmannsvik (Ed.), Robust arbeidspraksis - hvorfor skjer det ikke flere ulykker på sokkelen? (Robust work practice – why doesn't more accidents occur on the continental shelf?) Trondheim, Norway: Tapir Akademisk forlag.

Rosness, R. (2002). Slank og sårbar? In Forseth, U., & Rasmussen, B. (Eds.), *Arbeid for livet. Oslo, Norway*. Gyldendal Norsk Forlag, AS.

Røvik, K. A. (2007). *Trender og Translasjoner – Idéer som former det 21. århundrets organisasjon*. Oslo, Norway: Universitetsforlaget.

Skarholt, K., Hansson, L., Antonsen, S., & Hermundsgård, M. (2011). *Felles driftsmodell i Statoil: Hva er HMS-konsekvensene? (Common operation model in Statoil: What are the consequences for HSE?)* SINTEF report F18858.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. (2009). Integrated operations and leadership: How virtual cooperation influences leadership practice. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory methods and application* (*Vol. 1*, pp. 821–828). London, UK: Taylor & Francis Group.

Skarholt, K., & Torvatn, H. (2010). Trust and safety culture: The importance of trust relations in integrated operations (IO) in the Norwegian oil industry. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Reliability, risk and safety: Theory and applications* (*Vol. 2*, pp. 1285–1291). London, UK: Taylor & Francis Group.

Skjerve, A. B. (2008). Robust arbeidspraksis (Robust work practice). In R. Tinmannsvik (Ed.), *Robust arbeidspraksis - hvorfor skjer det ikke flere ulykker på sokkelen?* (*Robust work practice – why doesn't more accidents occur on the continental shelf?)* Trondheim, Norway: Tapir Akademisk forlag.

Verkerk, M. J. (2004). *Trust and power on the shop floor: An etnographical, ethical and philosophical study on responsible behaviour in industrial organizations*. Delft, The Netherlands: Eburon Academic Publishers.

Yukl, G. (1989). Managerial leadership: A review of theory and research. *Journal of Management*, *15*(2), 251–289. doi:10.1177/014920638901500207

Zand, D. (1997). *The leadership trial: Knowledge, trust and power*. New York, NY: Oxford University Press.

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Chapter 3
Creating an IO Capable Organization:
Mapping the Mindset

Bjørn-Emil Madsen
SINTEF, Norway

Lisbeth Hansson
SINTEF, Norway

Jan Eivind Danielsen
Bouvet, Norway

ABSTRACT

Integrated Operations (IO) is an organizational change and the mindset of the organization and the mindset of individuals affects this change process and vice versa. In this chapter, the authors discuss the changes introduced by IO, requirements to the change management process and a concept, they call IO Mindset. Change processes may be supported by use of tools and methods such as surveys and interviews. The chapter describes three different methods especially developed to assist IO change management processes, all including IO Mindset elements. The first one, TAM-IO, supports implementation of new ICT tools while CCP supports the change towards team based work forms. The third method, IO Mindset assessment is a newly developed tool, taking into consideration experience gained through implementation of IO and experience with other tools. Pilot testing of IO mindset assessment is described and discussed.

This work is based on the "IO Mindset project" performed in the "IO centre" (Madsen et. al, 2011).

INTRODUCTION

A major frame condition for reaching the state of IO, are the possibilities offered by new ICT tools. In fact, already in 2003, the petroleum industry in Norway declared that the application of ICT is a prerequisite as well as a driving force for the development of more integrated work processes within all main activity areas, such as drilling, operation and maintenance (OLF, 2003). To fully realize the potentials of the many technological innovations, teams and individuals both within

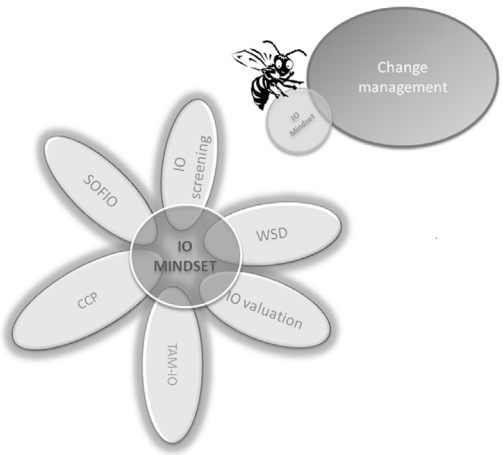
DOI: 10.4018/978-1-4666-2002-5.ch003

and across companies must utillize the technology efficiently in their practice. Thus, IO is to the same extent about work processes and work forms, as the bandwith of the optic fibre cables or data quality. As stated by Grøtan et al (2009) - from being primarily focused on technology development and application, the development of IO now takes new directions: - increased focus on challenges related to new work processes, integration of information throughout whole value chains and a wide recognition of the prime significance of human and organizational factors for the success of IO. As argued by (Moltu and Sæther, 2008), to better understand and implement IO, one need to take into consideration the different interactions between these key factors: ICT solutions, Architecture/workplace designs, Human capabilities, Organizing, Management, Work Processes and Work forms. These factors produce direct effects on the development and success of IO, as well as various interactional effects, as when new open office solutions are implemented, management must be performed in new ways.

Implementing IO is undoubtedly a major scale organizational change. Consequently, the need for a structured approach to transitioning individuals, teams, and organizations from a current state to a desired future state – change management (Filicetti, 2007), is evident. The human dimension is clearly a major transitive factor concerning the organizations ability to gain success within the other change dimensions of IO.

The IO Mindset concept was developed to better meet the challenges of managing the human dimension. The concept has emerged through working with Integrated Operation projects over the last decade and it has been operationalized into a mapping method. Several methodologies exist covering the human and organizational changes imbedded in IO, some of them represented in Figure 1. Methodologies such as TAM-IO, IO screening and CCP have been building stones

Figure 1. Methodologies applicable for IO change management processes



in IO Mindset assessment and visa versa. The insight and knowledge about the mindset of the organization and the individuals will fertilize the change management process.

The objective of this chapter is to give an introduction to the change management processes required when implementing IO. We will present some methodologies available for covering the human dimensions and specifically present the concept of IO Mindset and the tool IO mindset assessment.

CHANGE MANAGEMENT AND IO

Being one of the most frequently used terms within the oil- and gas industry for the last 10 years, there is still no common (in a strict sense) definition of Integrated Operations (IO). The concept's ambiguity is partly a consequence from the fact that IO also holds the aims and ambitions of how future operations will be carried out (Grøtan et al, 2010). Accordingly, IO encompasses many different needs agendas and *changes*, from the companies' top business strategic level down to how work is planned and performed in the sharp end.

Integrated Operations (IO) – Some Defining Traits

According to Wikipedia (www.wikipedia.org) IO refers to

[...]new work processes and ways of doing oil and gas exploration and production, which has been facilitated by new information and communication technology. Multi-discipline collaboration in plant operation is one example. IO has in a sense also taken the form of a movement for renewal of the oil and gas industry. In short IO is collaboration with production in focus.

More specific, as pointed to by Albrechtsen et al (2009) across companies and over time some distinctive agendas of the IO development have been, and still are:

- To maximize the utilization of Information and Communication Technology (ICT). Fiber optics, large data bases, advanced data models, semantic webs, simulators and a plethora of collaboration tools onshore, offshore and between on- and offshore are implemented
- By utilizing real-time data, onshore support, shared information and expert knowledge it is claimed that decisions and decision-making processes will improve and give "better, faster and safer decisions"
- To link different kinds of expertise into more efficient work processes, independent of time and space
- Increased value creation by reduced operational costs, longer life-span, accelerated and increased production, and higher HSE level. The industry has declared that this is the main driver of IO

As clearly evident, a major frame condition for reaching the state of IO, are the possibilities offered by new ICT tools. In fact, already in 2003, the petroleum industry in Norway declared that the application of ICT is a prerequisite as well as a driving force for the development of more integrated work processes within all main activity areas, such as drilling, operation and maintenance (OLF, 2003). Other factors on the business level are more efficient reservoir exploitation; optimization of exploration and operation processes; ambitions for long-term, managed development of fields and installations; and improved HSE performance (OLF, 2003, OLF, 2007). On the Norwegian continental shelf the value potential in implementing IO (for the periods 2005 – 2015), is estimated to 250 mrd. NOK in saved expences and increased income (OLF, 200?)

Today Statoil presents *their* view on IO in this way:

Integrated operations is a whole new approach to solving the challenges of having personnel, suppliers and systems offshore, onshore and in different countries.[....] Integrated operations (IO) involves using real time data and new technology to remove the divides between disciplines, professional groups and companies[....]Integrated operations is commonly associated with operative cooperation between sea and land. But there is a lot more to it than that. It's about how information technology that makes remote operation possible forms the basis for new and more effective ways of working. Real time transfer of data over great distances can be used to eliminate the physical distance between installations at sea and the support organization onshore, between professional groups, and internally our between the company and our suppliers.When working across professional boundaries [...], we are ensuring better value creation for the future. (http://www.statoil.com/en/NewsAndMedia/Multimedia/features/Pages/FactsAboutIO.aspx)

As stated above, Statoil are totally coherent with OLF (2003 and 2007) when it comes to what benefits and effects they see from IO. Among other

factors pointed out as significant, are changes in the relationship between on- and offshore when it comes to management, planning and location of expertise. Thus, what seems to have been one of the pinnacles of IO, has been the "Collaboration room"; a video-conference collaboration arena for on- and offshore managers, operators, planners, and engineers. There is different use of collaboration rooms across assets/installations. Some use it on a permanent use; also as office, others are using it as a meeting room. Interrelated with this, there has been a change in how onshore planning is conducted with more of the planning process done onshore by a mix of an onshore planner and offshore operators who rotate to land. In this way people experiences both to work onshore and offshore. Open office solutions have also been a part of this development. As Albrechtsen et al. (2009) points to, IO also is about the transfer of functions from offshore to onshore, thus a number of onshore activities gain increased importance for operational safety at offshore installations. However, the drive towards integration affects not only the division of activities between onshore and offshore, it also influence the relations between operators and contractors and between national and international actors.

The starting point of IO – the traditional modus operandi, have been coined "Generation 0" or "G-0." The first generation of IO (G-1), dealt mainly with integration and collaboration *within* the *operator companies*. The subsequent development of IO, referred to as "Generation 2" (G-2) establishes new operational collaboration between various actors in the industry, and represents a significant change in how operations are performed both on the continental shelf, in the onshore support services, and between expertice offshore and onshore.

To fully realize the potentials of the many technological innovations, teams and individuals both within and across companies must utillize the technology efficiently in their practice. Thus, IO is to the same extent about work processes and work forms, as the bandwith of the optic fibre cables or data quality. As stated by Grøtan et al (2009); from being primarily focused on technology development and application, the development of IO now takes new directions: - increased focus on challenges related to new work processes, integration of information throughout whole value chains and a wide recognition of the prime significance of human and organizational factors for the success of IO. As argued by Moltu and Sæther (2008), to better understand and implement IO, one need to take into consideration the different *interactions* between these key factors: ICT solutions, Architecture/workplace designs, Human capabilities, Organizing, Management, Work Processes and Work forms. These factors produce direct effects on the development and success of IO, as well as various interactional effects, as when new open office solutions are implemented, management must be performed in new ways.

However, implicit in some of these factors are new forms and patterns of communication, and new team constellations across traditional borders, equally relying on technology and people's social skills and atittudes in both direct and ICT mediated communication. In accordance with this Kaarstad et al. (2009) states:

The main challenge for IO today, is how the participants are interacting – more precisely, the participants' interaction skills. (p.1).

When it comes to interactive processes as knowledge mobilization, sharing and creation, challenges concerning trust and power between team members (co-located or distributed) are evident. So far such challenges seems mostly to have been underestimated by the industry. However, there seem to be a growing impact from the research based litterature on "virtual teams" e.g. by writers as Godar, S. H. and Ferris, S.P. (2004) and Driskell, J. E., Radtke, P. H. and Salas, E. (2003).

Integrated Operations – A Change in Five Dimensions

Summing up, IO can be viewed as a five dimensional concept. A illustrated in Figure 2, from the bottom; new or altered social processes, new or revised ways of performing work, new or revised division of work between on- and offshore, and on the top level – new relations and division of work between companies. Across these there is the premise giving dimension of ICT tools and solutions.

When it comes to corresponding, but not exclusivle related to each dimension, principle *change processes* the industry is undergoing, these are changing of attitudes and behaviors of personnel, structural changes, strategic changes, and technological changes.

CHANGE MANAGEMENT (CM) IN AN IO SETTING

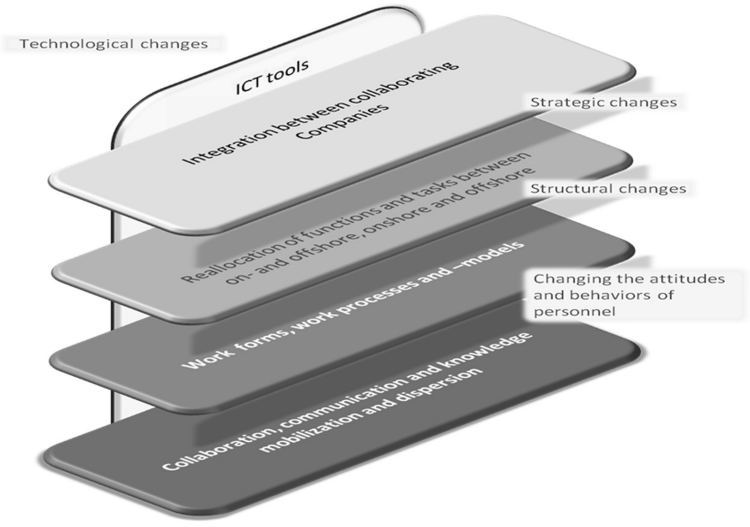
As previously shown, Integrated Operations hold many defining traits. Many of them obviously coincide with core elements of Knowledge Management. Another similarity between the two is the "tribal war" about who owns the concept – those who mainly focus on the data and hard-ware dimension, and those who focus on the human and social dimensions. However, there is seemingly no dissension about the amount of change IO represents in each organization, and for the oil- and gas industry at large.

In general organizational change may be observed along four dimensions;

- Strategic changes
- Technological changes
- Structural changes
- Changing the attitudes and behaviors of personnel

Clearly distributed across *all* these dimensions, implementing IO is undoubtedly a major scale organizational change. Consequently, the need for a structured approach to transitioning individuals, teams, and organizations from a current state to a desired future state – *change management* (Filicetti, 2007), is evident. However, the fourth dimension – the human – is clearly a major *transitive factor* concerning the organiza-

Figure 2. Dimensions of change in IO



tions ability to gain success within the other three change dimensions. The significance of the human dimension in change work and management is substantiated by U.S.Government Accountability Office's definition of CM

(CM is) activities involved in (1) defining and instilling new values, attitudes, norms, and behaviors within an organization that support new ways of doing work and overcome resistance to change... (http://www.gao.gov/special.pubs/bprag/bprgloss.htm):

The strength of this definition is that *resistance to change* is clearly pointed out as a major concern for change management, and it should be. Within the research on change processes –successes and failures, large bodies of evidence point to the inability to manage the people side of a business change, when the projects fail and change results are inefficient (Hiatt, J. and Creasey, T., 2010). Typical examples of resistance that change projects often fail to handle skillfully, are employees uncertainty concerning *why* change is called for, how change will *impact them personally*, and their (mis)conception of the organization's current state "If it is not broken, why are you trying to fix it?"(Hiatt, J. and Creasey, T., 2010). As evident in the works of major thinkers as Kotter (1996) and Lewin (1951), and many others, a key point when addressing resistance, is to create a state of *positive interest regarding the change process* building on a common acceptance of the positive outcome of undergoing a change, and the need for doing so now - urgency.

When Lewin (1951) published his Force Field Model, he argued that the motivational level for change is defined by the sum of positive (driving) and negative (resisting) forces within the individual and in his or hers working environment. However, to reach a desired state, he argued that this is best accomplished by removing resistance forces, rather than increasing driving forces.

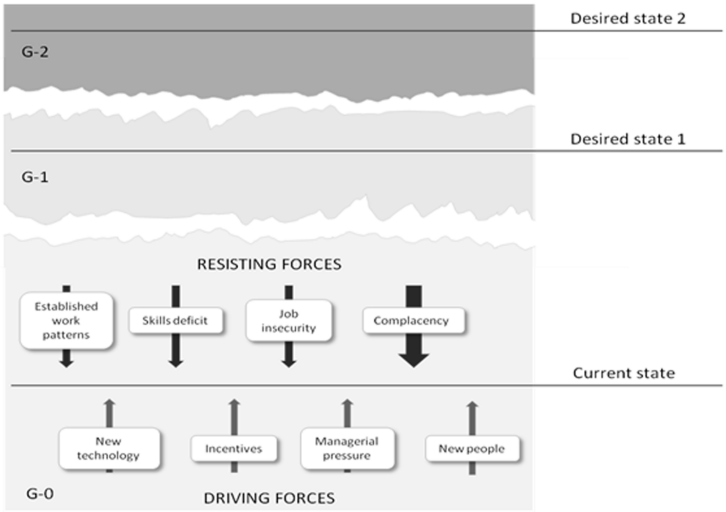
It is highly debatable if the fight for change *only* should be done by removing resistance. For one thing, in some cases too little of one factor constitutes a resisting force, when increased; the same factor will constitute a driving force, e.g. employee participation. Nevertheless, the main point in this model is the *dynamics* that lies behind people's willingness to change, and to what extent they are willing to change, and the need to identify and efficiently address the *most significant factors within this force field.*

As illustrated in Figure 3, Lewin's model is modified to cover the different IO "generations," hence the "G"s. The resisting and driving forces shown in the model are the same as in the original model published by Lewin (1951). The nature of these forces are general. In a concrete IO setting there might be other forces, and the forces present would most likely to some extent be different in the transition from G1 to G2. The relative strength among positive and negative forces may as well be different.

Taking this model as point of departure one easily can argue for the importance of knowing employees' starting position prior to a change process toward a new desired state. To start and complete a journey from a given current state to a significantly different desired future state is more compelling and easy for some than others. Thus, different mindsets and accordingly various levels of resistance, demand different actions to make different people arrive at the same level of change.

A model that addresses the psychological mechanisms involved both in change resistance (stages 1 -3), and in acceptance (stages 4 – 6), and the transition between them, is the Change Cycle Model (Salerno, A. and Brock, L.,2008). The strength of this model is firstly that it offers an analytic system to describe, understand and manage the "human irrationality" of change processes. Secondly it pinpoints the significant management challenge of bringing people through "The

Figure 3. Lewin's force field model (1951) modified



Danger Zone," from "Discomfort of change" to "Discovery of benefits from undergoing change." The Danger Zone represents the pivotal place where people make the choice either to move on to discover the possibilities the change has presented, or to choose some degree of fear, and return to prolonged resistance.

A majority of change programs fail. Among others Kotter (1996) stated that the success rate is only about 30%. This still applies. A significant part of the reason behind this, is that change management often fails to take into account how employees *interpret their environment and choose to act*. Accordingly, changing the way people work, rely on them accepting (the need for) change, which depends on persuading people to *think differently about their job and to see the opportunities offered by change*. In effect, management must master the difficult task of altering the mindsets of their employees (Lawson and Price, 2003). Employees will alter their mindsets only if they see the point of the change and agree with it – at least enough to give it a try. Taking into account that "What motivates management doesn't necessarily motivate employees" and "People like to write their own story instead of simply following the one you tell them," Lawson and Price (2003) points to four significant contributors to this process:

1. A compelling story, because employees must see the point of the change and agree with it
2. Role modeling, because they must also see the CEO and colleagues they admire behaving in the new way
3. Reinforcing mechanisms, because systems, processes, and incentives must be in line with the new behavior; and
4. Capability building, because employees must have the skills required to make the desired changes.

Each of these conditions is realized independently, but together they add up to a way of making behavior change thru altering people's attitudes about what can and should happen at work.

MINDSET AND IO MINDSET

Mindset is our way of thinking; a mental model through which we view the world. It is formed on the basis of our knowledge, beliefs, attitudes, and experiences, and it shapes our perspective on ourselves and the world around us. Carol S. Dweck defines in her book *Mindset* (Dweck 2008) that there are two types of mindset, the fixed and the growth. Based on her work on motivation and talent, Dweck uses these two set of mindset to explain how people have different ways of handling challenges and describe a specter of strategies to overcome challenges. People with a fixed mindset believe their basic qualities are fixed traits. On the other hand people with a growth mindset believe that they can develop their basic abilities. This view creates a love for learning and resilience that is essential for great accomplishments.

Dweck (2008) defines mindset in relation to strategies to overcome challenges in general. In this setting we want to narrow down and define mindset in relation to integrated operations. IO is a concept with several dimensions of new work modes funded on technological changes. A mindset in this setting, an *IO Mindset*, is a mental model of how we view the dimensions of Integrated Operations, i.e. new work modes and collaboration technology. We know that skills can be an important factor in forming our attitudes towards changes concerning technology. Therefore we also include skills in our understanding of the basis of IO Mindset together with knowledge, beliefs, attitudes and experiences.

Implementation of Integrated operation is a change process. Based on our mindset, it will be more or less easy to perform a required change. In difference from Dweck we are not defining different types of mindsets; still we would characterize a mindset as *high* or *low*. These characteristics are pointing to differences in gaps from where a person is today and the level or step which is required in an IO setting. A "high" mindset will make the step easier than a "low" mindset. But having a low mindset does not imply that you can't change. It is possible to learn and improve. But a person with "low" mindset will require more support, training and time than a person with a "high" mindset. In such process, a change in mindset must also be regarded as depending on the person's willingness to learn and to change. This is why mapping of the organization, team or personnel's IO Mindset is important as a starting point in an implementation process.

To sum up, an IO Mindset is defined as a mental model through which we view the aspects of integrated operations. IO Mindset is formed on the basis of our knowledge, skills, beliefs, attitudes, and experiences.

IO MINDSET AND CHANGE MANAGEMENT

The management's ability to establish new mindsets in the organization is regarded as a key factor in successful change processes. Consequently, there must be of great value to management *to know the present mind-sets, the "as is" state of both mind and practices of the people that are going to undergo specified behavioral changes.* In other words, the success rate of implementing IO, as any other major organizational change, could significantly rely on management's knowledge regarding the mindsets of the people that are going to be changed. To some people the various changes that are imbedded into the concept of IO, is a relatively small, easy and welcome step, for others IO represents an uncompelling step change. This difference might be a result of personality issues (conservative vs. innovative), it could be more related to professional issues (competence, practice, tools and processes), or both. Nevertheless, for those who find IO uncompelling, the transition from "discomfort" to "discovery," is a totally different and more challenging process compared to those who find IO compelling.

As pointed to by Filicetti (2007) change management is about transitioning individuals, teams, and organizations from a current state to a desired future state. Consequently, knowing how "forward compatible" people are, and the gap between "as is" and "to be," is clearly a good starting point in designing and/or deciding measures to introduce and effectively implement the actual changes known as IO.

IO MINDSET MAPPING METHODS

IO Mindset mapping identifies needs for training, development and incentives through use of dedicated methods. Many methods exist for support of change management processes, but those described in this chapter has been developed, adapted and used in an IO setting. As integrated operations influence people, organization, work processes and technology, we need methods which cover all these elements. The methods described in this chapter are:

- Collaboration Complexity Profile (CCP)
- Technology Acceptance in Integrated Operations (TAM-IO)
- IO Mindset assessment

COLLABORATION COMPLEXITY PROFILE (CCP)

Collaboration and teamwork including interdisciplinary workgroups and distributed teams is a prevailing work form in IO. The complexity of this collaborative work increases with increasing number of disciplines, number of members in the group, numbers of sites in a distributed team and with complexity of the task. The Collaboration complexity profile (CCP) offers a framework for evaluating and understanding the variety of challenges implicit in collaborative work. The CCP tool may be used both as an evaluation tool and as a process tool. CCP offers a "language" for the members of a team to communicate about their collaboration or teamwork and based on the resulting profile they can define actions for improvement of the teamwork quality.

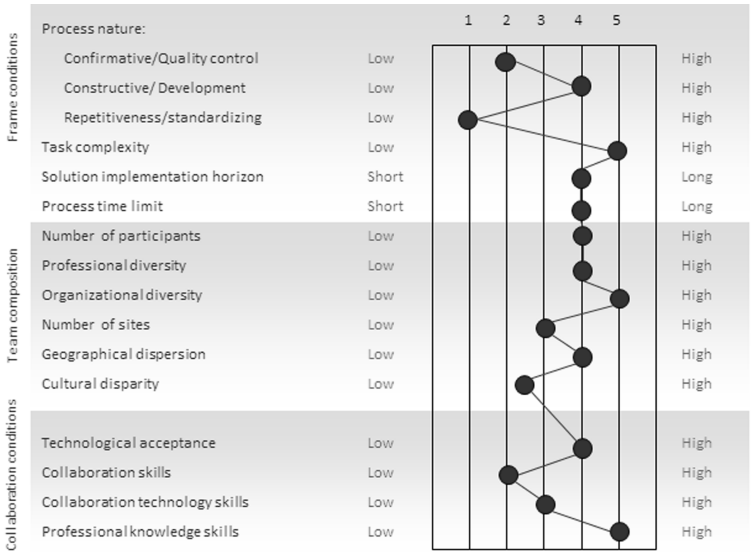
CCP is currently under development at SINTEF and exist in different versions. The version presented in Figure 4, covers three main dimensions; *frame conditions*, *team compositions* and *collaboration conditions*. Each dimension is described through several factors. The process nature, task complexity and available time are typical factors for the dimension "frame condition." Team composition is described by factors such as the number of participants, the professional diversity, organizational diversity, geographical dispersion of the team and cultural disparity. When it comes to collaboration technology, this dimension is described through factors such as; technological acceptance, collaboration skills, collaboration technology use skills and professional skills.

The profile appears when we (or the team) score each factor along a scale from 1 to 5. At the boarder of the profile it is indicated long vs short, high vs low indicating the strength of each factor. High scores in *frame conditions* and *team compositions* show that the actual collaboration process is highly challenging and must be approached accordingly. Low scores in *collaboration conditions* indicate that the team is relatively short on basic preconditions for succeeding, and needs to further develop their platform for collaboration.

CCP also explores team skills and qualities in more detail by factors such as:

- Problem solving/decision making skills
- Shared and compelling goal
- Shared understanding of roles and responsibilities
- Shared understanding of problem to be solved
- Commitment to task
- Objectivity
- Mutual respect, tolerance and trust

Figure 4. Illustration of Collaboration Complexity Profile (CCP)



- Conduction open communication
- Supportiveness
- Adapting to other members' styles
- Compensating for each other

In testing CCP as a process tool we experience that the participants in the process gain more insight in their own collaboration situation. By describing and scoring the factors the different aspect of the collaboration situation become clearer and makes it easier to identify skills which needs improvement.

TAM-IO (TECHNOLOGY ACCEPTANCE MODEL FOR INTEGRATED OPERATIONS)

TAM-IO is a survey method for evaluation of acceptance of ICT related to IO. TAM-IO has been developed by SINTEF as a part of the IO centre program 1 (Drilling and well) and the model uses a survey for evaluation of technology acceptance (Lauvsnes and Korsvold, 2010). The term "technology acceptance" is widely used within the organizational research literature and covers the Man, Technology and Organizational (MTO) aspects of implementation of new ICT in organizations.

The main theoretical framework for TAM-IO is the Technology Acceptance Model (TAM), developed by Fred Davis (Davis, 1989), is an adaptation of the theory of reasoned action (TRA) which is a model designed to explain virtually any human behaviour. TAM is specifically tailored to explain computer usage behaviour, and has proven to be a useful theoretical model in helping to understand and explain use behavior in Information System implementation. It has been tested in many empirical researches and the tools used with the model have proven to be of good quality and to yield statistically reliable results (Legris et.al 2003).

A key purpose of TAM is to provide a basis for tracing the impact of external variables on internal beliefs, attitudes and intentions. TAM points that two particular beliefs, perceived usefulness and perceived ease of use are of primary relevance for computer acceptance behaviours. Davies et. Al. has proposed a new version of his model: TAM2

(Venkatesh & Davis, 2000). This also includes intermediate variables.

The model describes how the usage of the ICT tool is decided by the users intention to use it. The intention of use is decided by the perceived usefulness of the ICT tool and perceived ease of use. The perceived usefulness is predicted by two different processes, the social influence processes and cognitive instrumental processes. The social influence processes mainly includes social norm and image. The cognitive instrumental processes includes factors like job relevance, output quality and result demonstrability. The experience with the current ICT tool and previous ICT experience influence on both subjective norms and the intention to use the tool.

In addition to the TAM model the TAM-IO survey has been constructed by elements from "Team reflector," a SINTEF-developed offshore survey regarding primarily HSE. Experience and knowledge from the development of the IO Mindset mapping activity has been essential in the development of TAM-IO.

TAM-IO is a web based survey and questions are answered on a scale from 1 to 5, with 1 indicating "strongly disagree" and 5 indicating "strongly agree." Examples of questions from the survey are given below; "the technology" is in the survey changed to the name of the relevant ICT tool:

- It will be easy for me to learn to use "the technology"
- I will easily become a skilled user of "the technology"
- Using "the technology" will increase my productivity
- Using "the technology" will make my job easier
- I intend to use "the technology" when it becomes available
- Management will expect me to use "the technology"
- I see the need to work together in a team
- The team members share knowledge and skills
- "The technology" will increase the level of safety

TAM-IO has been used to support implementation of decision support tools in drilling.

IO Mindset Assessment

The IO Mindset assessment is another survey based method developed as a generic tool to use prior to IO initiatives such as establishing a new onshore decision and support centre. The tool uses elements from the TAM-IO survey and a survey measuring support to offshore organization from onshore (Korsvold et al, 2009). In addition mindset elements such as "openness to change," "attitude towards teamwork," opinion of collaboration means such as videoconferences are included. IO Mindset assessment is useful to support changes to work forms as well as introduction of new ICT tools.

A typical IO team is geographically distributed between the offshore installation and the onshore support team. One part of the survey concerns collaboration across the onshore – offshore axis and some of the questions used to shed light on this subject are:

- Frequency of contact? Several times per day, every day, every week, more infrequent
- What is the contact about? Information exchange, decision making, problem solving
- Means of communication? Video, telephone, e-mail, net-meeting or physical meetings.

Then there are questions concerning the opinion on communication means (videoconferencing, net-meeting and so on):

- These communication means improves the quality of our work
- Use of these communication means increases the probability of failure
- These communication means are difficult to use

These questions are rated from 1 to 5, 1 meaning "disagree" and 5 meaning "agree." The same rating is used for the following questions as well, concerning the individuals attitude towards changes:

- It is stimulating to try new ways of working
- I prefer unchanged work routines
- I like changes and is bored when I have to do thing the same way all the time
- I feel a little tense when I am informed about changes in plans

Teamwork and collective work forms are covered by questions such as:

- I prefer to work together with others
- I enjoy working in a team
- I am more effective in my job if I am a part of a group
- I am disturbed when I have to work i the same room as others

Questions are also included regarding existing or new ICT tools.

- "The tool" is user friendly
- "The tool" makes us better coordinated
- "The tool" support the reporting in a good way
- "The tool" makes us well integrated with other departments
- "The tool" is an efficient tool

Other parts of the survey cover the organization in general and the quality of change management processes.

PILOT TESTING OF IO MINDSET ASSESSMENT

Case Description

A major oil and gas operator with an extensive IO experience is going through with a re-vitalization of their top side inspection system and related work processes; an IO intervention process. As part of the company's standard methodology, all new IT implementation projects must model all related work processes as-is and to-be using the company standard process mapping tool. The IT specification is written with the basis of the to-be processes that have been signed off by appropriate line mangers and discipline representatives.

The new IT system is being tailored for the operator, using their long experience for creating an inspection system that handles the whole loop of inspection from; risk ranking systems to set inspection intervals (RBI), monitoring degradation, manage equipment groups, plan and schedule inspection, perform reporting, analyze findings before updating equipment with new information. The specification of the system has been based on a best practice Integrated Operation approach where onshore and offshore tasks are seamlessly integrated and where an Onshore Inspection Center (OIC) will coordinate and support the execution of the inspection process.

With this approach the project has created an integrated to-be solution of IT systems and work processes together with physical office locations and new roles and responsibilities. Such a creation of integrated to-be solution demand a massive involvement and multi-disciplinary analytical skills. The first challenge is to create an integrated enterprise architecture encapsulating people, processes, IT systems and governing requirements. The next challenge is to create a roadmap on how to build and implement the solution and the last is the actual implementation effort, doing the needed adjustments along the way. The most important aspect of it all is maintaining a precise

picture of the asset integrity of top side systems along the way.

The company had decided to execute the project based on a business case with an expected return on investment. The company has therefore done a baseline measurement on fiscal and operating KPI's together with a survey internally in the inspection department and with their closest partners.

A new measurement and survey is scheduled some time after the main effects are expected to have taken place. By using other departments' similar KPI's for the same period as reference and by interviewing key people following the second survey, a return on investment will be estimated.

Change Management in the IO Intervention Process

Change management has been a major focus throughout the IO intervention process. A massive amount of documentation from earlier mappings of areas of improvement has been analyzed. All offshore shifts have been involved in workshops and employee representatives are part of the steering committee. The two main parts of the change effort; the IT project and establishing the inspection center have key people involved in both steering committees and project groups. This has secured a firm integration between the two parts of the change process.

Users and discipline leads have been involved in writing the specification for the inspection IT system, designing to-be work processes and for being part of the test and acceptance of the system as modules are ready. The onshore operation center project has been run by the key roles that are collaborating onshore-offshore. They have created a coordination center prototype, they have structured key meetings, common task management system, and a mobile support phone for offshore to call for assistance and a video conference solution. The inspection department has started using the existing top side inspection IT system in new ways to start implementing the new work processes that will be better supported in the new system.

IO Mindset assessment has been used to establish the organizations baseline and during the change process of implementing the new work processes, inspection IT-system and support center. The first assessment addressed in this chapter, gives a picture of status quo and will give the change process goals to target and focus on. The second and third assessment is to be done after changes have taken place. Based on the three assessments any changes in data can be further investigated by interviewing key personnel.

Accompanying the IO Mindset assessment is monitoring of the Key Performance Indicators (KPI's) of the unit that has implemented new IO elements. These KPIs are also retrieved for two other business units acting as reference groups since they have not gone through important changes in the same period. By eliminating impact on KPIs from external sources and the general continuous improvement in the business units, an estimated return on investment on the IO implementation can be estimated.

IO Mindset Assessment as a Part of an IO Intervention Monitor Tool

To measure to what extent the IO initiatives would reach the ambitious project goals, the IO Intervention monitor tool complimented the IO Mindset assessment with measures of key indicators that are key goals for the two change initiatives.

- Response time; the time from an issue is raised onshore or offshore until the responsibility for solving it is taken by the right people.
- The perceived level and quality of coordination and collaboration onshore/offshore
- The perceived quality of work performed in the inspection work process
- Their relations to the existing IT tool and how well it supports their tasks in the work process
- Their expectations towards the coming inspection centre

Change Elements of the Case

As previously shown, the changes associated with implementing IO could be described along four main dimensions:

- Strategic
- Structural
- Technological
- Attitudes and behavior

In our case, during the first part of 2011, the Inspection planing and coordination group/team has moved out of their cubical offices into a new-built center/open office solution.

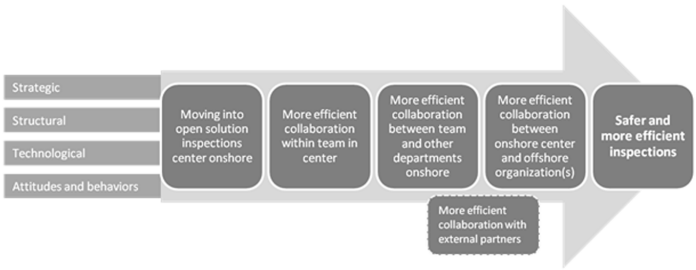
As Figure 5 shows, the initial action of moving people into the open office solution of the inspection center, is the first step on the way towards the strategic goal of "safer and more efficient inspections." Intermediate goals/steps on the way, are collaboration improvements within the inspections team, between the team and other departments/experts onshore, and between onshore and offshore experts. The main focus has been on company internal personnel, but as the figure indicates, there have been performed some actions to prepare for integrating experts from collaborating external partners.

As further illustrated in Figure 5, the structural change of altering the physical layout of the inspection team's workplace also involve changes regarding the employees attitudes and behaviors, partly determined by changes in the technology they use. The strategic change of employing enhanced collective work forms, may be argued to be funded both on the supply of new technical solutions as well as the recognition of the power of teams and collective work forms vs. individuals and serial work forms.

Therefore, the four main change dimensions, in various composition, are present in all stages of the overall change prosess regarding the company's planning and support of inspections.

The change in the strategic dimension is about bettering the utilizing of available knowledge to achieve safer and more efficient inspections. This is good both for the company's reputation/position in the industry and their economy. (In this respect, IO bears obvious resemblance with Knowledge Management). The structural change is about physical work-place layouts, technological infrastructure and how work is to be performed (work processes and governing documentation) and how the formal organization is re-designed to support this. The technological change is about implementing new ICT solutions both for single-profession problem-solving and for various types of communication and collaboration between various experts both directly and virtually. In this case initially the team must adapt to a new physical work place layout and new ICT tools and solutions. Accordingly, they must change their ways of thinking and working together; firstly among themselves, secondly with other teams and experts within their own company– directly and virtually. Thirdly they must extend

Figure 5. Change elements of the case



their collaboration with experts outside their own company. The behavioral and attitudinal changes that (must) take place to master the IO "environment, are among other things:

- The proper use of new technology
- The group dynamics of decision processes (thru increased concurrency and collaboration)
- The increased transparency concerning the team members' *knowledge, skills (and attitudes)*
- The importance of trust both within and between teams and various experts

The willingness and capability to undergo such changes depends partly on people's *general* change readiness, but mostly *their change readiness towards the IO specific solutions they are about to experience* – their IO mindset(s). Consequently, to obtain success and release the potential in the technological and organizational changes, the company must know the IO-mindset within the teams. This in order to design and employ efficient *change management processes/measures*.

Results from Pilot Testing of IO Mindset Assessment

The first run of the survey was distributed just before the onshore inspection group moved into the inspection centre. A new ICT planning tool was going to be introduced some months later and we chose to include questions about the existing planning tool. Some of the interesting results from the survey are presented in this section.

Today there are little communication between onshore and offshore and limited use of IO communication means such as videoconferencing and net-meeting. A majority of the respondents expect that the new way of communicating will improve the quality of their work and they believe that it will be easy to learn to use the new communication means. All in all they have very positive expectation towards closer collaboration between onshore and offshore. The inspection group is quite unanimously across onshore and offshore when it comes to the expectations to the improved communication enabled by the new IO related communication means as is illustrated in Figure 6. Between 55 and 75% think that the new way of communication will enhance the quality of their work, will be ease to use and will not increase the probability of failure.

Establishment of the new inspection centre onshore (OIC) is also met with great enthusiasm and most of the respondents expect the centre to improve coordination and effectiveness in the inspection department. The response time, which means the time the offshore personnel have to wait for the onshore centre to respond and visa versa, has been one main concern. As illustrated in Figure 7 between 50 to 80% expect the operation centre to improve the coordination within the department, shorten the response time and improve efficiency and safety.

Establishment of the inspection centre and the improved communication between onshore and offshore introduces a more team based work form. The survey included several questions about the view on this team based work form (see Figure 8). It is interesting too see that while most of the respondents say they both enjoy and are more efficient when they work in a team, they will have problem with concentration if they have to share the work space with others. This may indicate that there are some resistance against moving into the support centre onshore, where they will be co-located and will not keep their cell offices.

To be able to prepare the inspection group for the new planning tool, questions about the existing planning tool were included in the survey. More that 60% find that the existing programme is both user friendly and easy to use. Using the tool does however not motivate them. Further, the results describe quit clearly that the existing

Figure 6. Survey results, opinion of new communication means

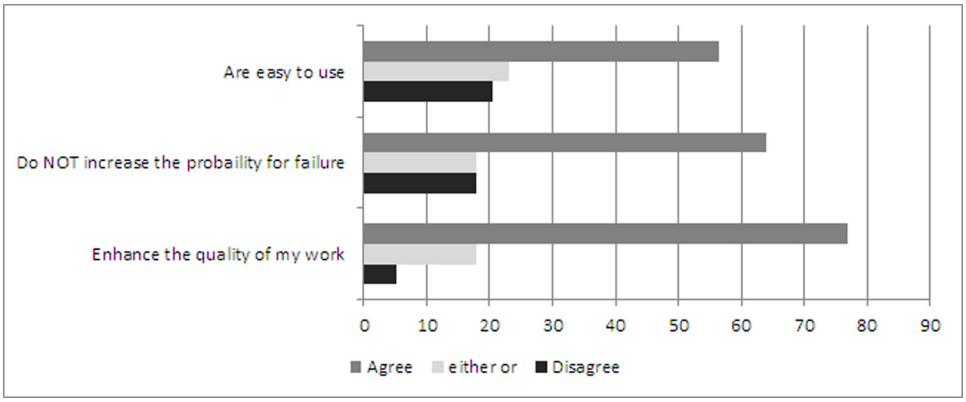


Figure 7. Survey results, expectations to the OIC

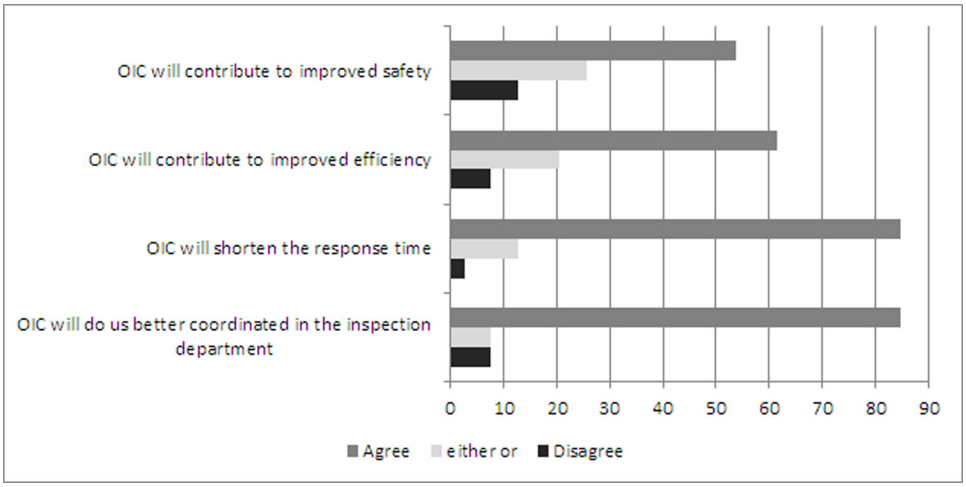
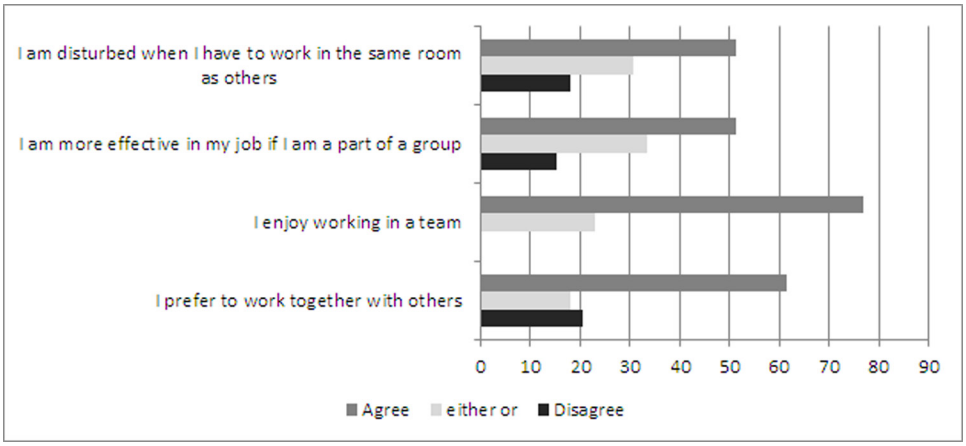


Figure 8. Survey results, attitude towards team work



planning tool does not support coordination with other departments. Additionally, the planning tool is not well integrated with the other tools, such as administrative tools. These findings should be used for motivation towards a new planning tool.

DISCUSSION OF IO MINDSET ASSESSMENT PILOT TESTING

Management of the organization or individuals mindset in an IO change process is a success factor. In this paper we have described methods developed and used to assist the change processes in IO, methods that take IO mindset into consideration. Most attention has been given to IO Mindset assessment and the pilot testing of this tool.

The pilot testing of IO Mindset assessment was made for an inspection department in an oil- and gas company which was about to implement an IO initiative. An onshore inspection centre was established, improved coordination within the department was aimed at and a new planning tool was on its way. With relatively little effort, the survey gave a lot of interesting information about the organization and the ongoing process. The organization seems to be ready for change, the expectations are high and the process should be handled with care to avoid disappointment. It is obvious that the department today is not "one" team, this is based on the fact that the answers from the onshore part and offshore part are significant different. It is however obvious that they are ready to take a huge step toward a more common culture and more communication in the virtual onshore-offshore team. The expectation to the effect of introducing a new inspection centre onshore is very high.

In other projects we have seen a mistrust from the offshore organization when videoconferencing is introduced, they are afraid that this is a part of a surveillance system. When it comes to the inspection department, most of the employees both onshore and offshore are positive towards the enhanced collaboration and use of video conferencing and net-meeting. The change management process in front of the survey has probably opened the minds of the organization. This is underlined by the fact that they anticipate the new communication means to be easy to use. The company also has a long track record within IO and has made it an everyday event to have a meeting with offshore using net meeting and video conferencing.

The existing planning system is quite popular and it is obvious that it may not be easy to introduce a new system. But, the knowledge gained from the survey can support this introduction by focus on the part of the system the respondents agree do not function well. When we see their ability to face new system such as videoconferencing however, it may not be difficult to introduce the new planning system after all.

The organization is quit open to changes in general. The IO mindset as it has been described in this chapter may be described as "high" for the inspection department. If it was "high" in front of the change process or if it has turned "high" as a result of the change process can not be read out from the survey results alone. The survey covered around 40 respondents and it was anonymous. From the results we see that there are some individuals more resistant to change, with a more negative view of the "new" inspection department. The managers should take this into consideration in the following process. If you treat those with a "low" IO mindset as they have a "high" IO mindset, the resistance could be even higher. By presenting the overall results from the survey to the group as a hole, this could affect the mindset of the resistant people if done in a good way. As described earlier, having a low IO mindset does not imply that you can´t change, but it will require more support, training and time.

FUTURE RESEARCH DIRECTIONS

As the acknowledgement of the human change elements of IO eventually seem to spread and are given it's proper attention, IO Mindset assessment offers a methodology to empirically support sound and efficient change management. However to prove it's relevance and agility, further validation is called for. The need for such a tool is supposedly increasing, given the quest for reaching IO generation two, further pushing the envelope when it comes to collaboration and integration across traditional boarders. On this background we urge for further research along the human dimensions of IO interventions.

CONCLUSION

In this chapter we have described and discussed the change processes introduced by IO and especially addressed the mindset of the organization and the individuals. Based on the work with the IO Mindset concept it was realized that none of the existing methods covered the elements of IO mindset and this was the point of departure for the IO Mindset Assessment tool. This tool has been tested on a pilot and it looks promising so far.

IO Mindset assessment seems to "close the gap," taking the human dimensions in IO implementation into consideration. It is obvious that the survey should be designed to the specific organizational unit and their change process. It will however be possible to build up a database of good questions to be used in these surveys. The survey should be developed in close cooperation with someone who knows the organization well; it is import to be aware of the right phrases to use. The IO Mindset assessment results are valuable input to the change management process, as we have seen for the pilot testing. These results can also give indications of further activities to be made for instance in-depth interview to capture detailed information, use of other tools such as TAM-IO to clarify more details with new ICT tools or use CCP if challenges with collaboration and teamwork are revealed.

The success rate of implementation of IO, could significantly rely on managements knowledge regarding the mindset. IO Mindset assessment seems to close this gap in an appropriate way by giving support and advice to the change management process.

REFERENCES

Albrechtsen, E., Grøtan, T. O., Skarholt, K., & Hermundsgård, M. (Forthcoming). *Risk governance: pre-assessment of Integrated Operations. Concepts and cases, possibilities and threats.* SINTEF draft report, to be published on www.sintef.no/rio

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *Management Information Systems Quarterly*, *13*(3), 319–340. doi:10.2307/249008

Driskell, J. E., Radtke, P. H., & Salas, E. (2003). Virtual teams: Effects of technology mediation on team performance. *Group Dynamics*, *7*, 297–323. doi:10.1037/1089-2699.7.4.297

Dweck, C. (2008). *Mindset: The new psychology of success*.

Filicetti, J. (2007). *Project management dictionary*. Retrieved from http://www.pmhut.com/pmo-and-project-management-dictionary

Godar, S. H., & Ferris, S. P. (2004). *Virtual and collaborative teams*. Hershey, PA: Idea Group Publishing.

Grötan, T. O., Albrechtsen, E., Rosness, R., & Bjerkebaek, E. (2010). The influence on organizational accident risk by integrated operations in the petroleum industry. *Safety Science Monitor, 1*(14).

Hiatt, J., & Creasey, T. (2010). *The definition and history of change management.* Retrieved from http://www.change-management.com/tutorial-definition-history.htm

Kaarstad, M., Rindahl, G., Torgersen, G.-E., & Drøivoldsmo, A. (2009). *Interaction and interaction skills in an integrated operations setting*. Presented at IEA 2009, 17th World Congress on Ergonomics. August 9-14, 2009 Beijing, China.

Korsvold, T., Hansson, L., & Lauvsnes, A. (2009). *Approaching and creating new work practices through action research – A case study from implementation of integrated operations (IO) in a Norwegian oil and gas company.* EGOS conference, Barcelona Spain 2009.

Kotter, J. P. (1996). *Leading change*. Boston, MA: Harvard Business School Press.

Lauvsnes, A., & Korsvold, T. (2010). *Development and validation of technology acceptance model for integrated operations (IO) – TAM-IO*. SINTEF Report F17610.

Lawson, E., & Price, C. (2003). The psychology of change management. *McKinsey Quarterly, June*. Retrieved from https://www.mckinseyquarterly.com

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, *40*, 191–204. doi:10.1016/S0378-7206(01)00143-4

Lewin (1951). *Field theory in social science: Selected theoretical papers*. New York, NY: Harper and Bros.

Madsen, B. E., & Hansson, L. (2011). *Closing the gap*. (SINTEF F216540).

Moltu, B., & Sæther, G. (2006). *Betre samhandling mellom hav og land – Evaluering av OPS rom i HNO*. Trondheim. STF50 F06057.Sintef

OLF. (2003). *eDrift på norsk sokkel – det tredje effektiviseringsspranget*. OLF-rapport.

OLF. (2006). *Verdipotenisalet for Integrete Operasjoner på Norsk Sokkel*. OLF-rapport.

Salerno, A., & Brock, L. (2008). *The change cycle: How people can survive and thrive in organizational change*. Williston, ND: Berrett-Koehler Publishers.

Statoil. (n.d.). *Facts: Integrated operations*. Retrieved from http://www.statoil.com/en/NewsAndMedia/Multimedia/features/Pages/FactsAboutIO.aspx

Strasunskas, D., & Tomasgard, A. (2009). *In quest of ICT value through integrated operations: Assessment of organizational – technological capabilities.* IO centre home page.

The, U. S. Government Accountability Office. (n.d.). *BPR glossary of terms*. Retrieved from http://www.gao.gov/special.pubs/bprag/bprgloss.htm

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four Longitudinal field studies. *Management Science*, *46*(2), 186–204. doi:10.1287/mnsc.46.2.186.11926

Wikipedia. (n.d.). *Forward compatible*. Retrieved from http://en.wikipedia.org/wiki/Forward_compatible

Wikipedia. (n.d.). *Integrated operations*. Retrieved from http://en.wikipedia.org/wiki/Integrated_operations

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Chapter 4
Collaborative Work Environments in Smart Oil Fields: The Organization Matters!

Ewoud Guldemond
Atos Consulting, The Netherlands

ABSTRACT

In the last decade, oil companies are increasingly viewing collaborative work environments as an important component of their smart oil fields programs. Collaborative work environments (CWEs) have been implemented by several major oil companies, to support the use of technology in smart oil fields. The implementation of these collaborative work environments is not without problems. After major oil companies successfully implemented the hardware, tools and applications in CWEs, organizational design challenges remained unsolved. The biggest challenge is to change behavior of staff and to effectively integrate people across disciplinary boundaries. This chapter emphasizes the importance of the organizational aspect of CWEs in smart oil fields. The objective of this chapter is to provide the upstream petroleum industry with guidelines for the organizational design of the collaborative work environments, in support of the operation of smart oil fields. In order to provide the organizational design guidelines, a PhD research was conducted at three different operating units of a major oil company. This research focused on the business processes, organizational structure, and competencies of staff in the CWEs.

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INTRODUCTION

The upstream[1] petroleum industry is undergoing a period of significant change (Knoppe & Holloway, 2008). In this research, three current business challenges in the upstream petroleum industry are distinguished: *(*1) increasing demand for energy (Hickman, Guidry & Seaton, 2008; Rawdon, 2003). The increase in world population, economic growth per person, and importance of transport/ mobility, result in increasing demand for energy (Brufau, 2008). These demand requirements push oil companies to maximize their production from both existing and new oil and gas fields (Bartram & Wood, 2009). (2) Operating in difficult oil fields (Brufau, 2008; Hickman, Guidry & Seaton, 2008; Rawdon, 2003; Saggaf, 2008). Oil companies claim that there is hardly any easy accessible oil reservoir left. Most of the large oil fields have been exploited since the 1960s and 1970s; therefore their production has declined significantly in the last two decades (Babadagli, 2005). As the 'easy' oil and gas reserves become increasingly scarce, the upstream petroleum industry is aware of the need to develop unconventional resources in more complicated operating environments (Yawanarajah *et al.,* 2008). Unconventional resources include heavy oil, ultra deepwater oil and gas, tar sands and gas-to-liquids (Miskimins, 2009; Tye, 2010; Yawanarajah *et al.,* 2008). (3) The Big crew change (Brett, 2007; Edwards, Saunders & Moore-Cernoch, 2006; Heaney & Davidson, 2006; Hickman, Guidry & Seaton, 2008; Knoppe & Holloway, 2008; Popham & Edwards, 2009; Tealdi, Kreft & Donachie, 2006). The workforce in the upstream petroleum industry is diminishing, both in numbers and experience (Popham & Edwards, 2009). Within the industry this is referred to as 'the Big crew change'. The industry is facing difficulties in attracting smart young graduates (Tealdi, Kreft & Donachie, 2006). As a result of a large proportion leaving the industry, and fewer graduates entering the industry, a big gap in experience occurs. This big gap is partly caused by the major lay-off of staff in the 1980s, who have not returned to the oil companies (Treat *et al.,* 1994).

Most major oil companies introduced 'Smart Oil Fields' to deal with the current issues. The implementation of Smart Oil Fields often requires a transformation of work processes and staff (Van den Berg, 2007). Smart Oil Fields Technology enables oil companies to reduce costs, increase production, and increase recovery[2] factor (cf. De Best & Van den Berg, 2006; Henderson, 2005; Murray *et al.,* 2006). Major oil companies have implemented Smart Oil Fields concepts in various oil and gas fields around the world, in order to make better decisions, which result in increasing production and recovery of oil and gas (Van den Berg, 2007).

Collaborative Work Environments can be perceived as the platform on which Smart Oil Fields operate. Collaborative Work Environments are being implemented by the petroleum industry to access data (which results from the Smart Oil Fields Technology), in order to enhance collaboration and decision-making between locations (Van den Berg, 2007).

The focus of this chapter is on the organizational design of Collaborative Work Environments.

In the remainder of this chapter, the implementation of Smart Oil Fields, and an introduction to Collaborative Work Environments is provided. Afterwards, the observed challenges of Collaborative Work Environments are discussed. In addition, guidelines to deal with the observed challenges of Collaborative Work Environments for the upstream petroleum industry are provided. In the last section, conclusions are drawn and future directions are indicated.

BACKGROUND

How do Business Challenges and Business Objectives Influence a Real Oil Field?

In general, the upstream petroleum industry distinguishes only one business process for production: the physical extraction of oil and gas (Cassells, 1999). In turn, this business process is further divided into four control loops, based on different time scales for the decisions involved: (1) Real-Time Operations (with a timescale of 1 second – 1 day); (2) Production Optimization (with a timescale of 1 day – 3 months); (3) Well and Reservoir Management (with a timescale of 3 months – 2 years); and (4) Field Development Planning (with a timescale of 2 – 10 years). Oil companies are aiming to reduce their costs, increase their production and recovery factor. Figure 1 combines the business challenges and the four control loops of a real oil field (based on Guldemond, 2011).

Most major oil companies introduced 'Smart Oil Fields' to deal with the business challenges and to achieve their business objectives. These Smart Oil Fields are models (simulations) of real oil fields.

IMPLEMENTING SMART OIL FIELDS

A 'Smart Oil Field' is: "A context where the combination of (a) hardware and systems; (b) data and standards, and; (c) people and skills, enables the organization to access difficult oil fields, and to provide it with real time data of the actual situation of petroleum production and reserve quantity" (Guldemond, 2011, p. 21). Figure 2 represents a Smart Oil Field for better decision-making.

The evolution of Smart Oil Fields consists of four phases (Edwards, Mydland & Henriquez, 2010, pp. 3-5):

- **Phase I – Technology Focus**: At first, the major focus was on the data, information technologies and building multidisciplinary work environments, also known as 'Collaborative Work Environments';
- **Phase II – People, Process, Technology:** In the next phase the focus was on the development of the People Process Technology (PPT) approach. The importance of business processes, people and change management was recognized;
- **Phase III – People, Process, Technology and Organization (PPTO):** In the third phase of the evolution was to move to ca-

Figure 1. Business challenges and control loops in a real oil field (based on Guldemond, 2011)

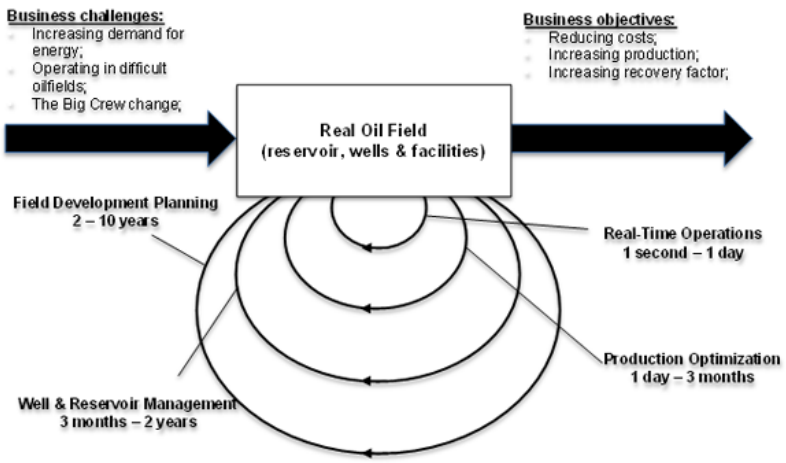
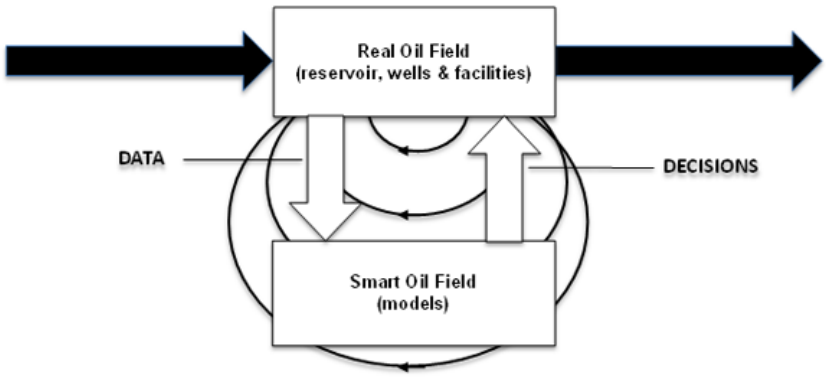


Figure 2. Implementing a smart oil field for better decision-making



pability delivery and recognizing the fact that organizational change and governance was key in delivering Smart Oil Fields implementation. The PPTO approach must have all of the following key elements in place:

- **Business Process**: What is the core value process and underlying process that is to be improved and updated to deliver the new capability?
- **Technology**: What technologies are needed to deliver the new capability?
- **People/Resource**: What skills, competencies and behaviors are needed to execute the capability, process and use the support technologies?
- **Organization/Governance**: What organizational structures, incentives and relationships are needed to execute the value adding capability?

- **Phase IV – Capability Platform:** One step further is an integrated set of capabilities that can be scaled across a global business and provides a platform for continuous improvement and innovation.

Smart Oil Fields consist of Smart Oil Fields Technology and Collaborative Work Environments (CWEs). This chapter primarily focuses on the processes and organization/governance and secondary on people/resource (as described in phase III – People, Process, Technology and Organization) in Collaborative Work Environments.

Introduction to Collaborative Work Environments

Currently, Collaborative Work Environments are being more and more applied in several industries, for example in the military (cf. Bayerl et al., 2008; Benford et al., 2001; Popham & Edwards, 2009), in flight control (Bayerl et al., 2008) and in the petroleum industry (cf. Adefulu, 2010; Bayerl et al., 2008; Knoppe & Holloway, 2008). Collaborative Work Environments provide industries with new opportunities for cross-functional collaboration, which was not the case in the past. Although other industries use similar CWE concepts, the contexts of these industries differ from the petroleum industry's context (Bayerl et al., 2008). According to Bayerl et al. (2008) it remains unclear to what extent findings from other industries (like flight control and military) are directly applicable to the upstream petroleum industry.

In the last decade, oil companies are increasingly viewing Collaborative Work Environments as an important component of their Smart Oil Fields programs (Vindasius, 2008). Collaborative Work Environments have been implemented by several major oil companies, to support the use

of technology in Smart Oil Fields (Guldemond & Ten Have, 2008). The CWE dedicated work space is equipped with advanced hardware and software systems, like video-conferencing/audio, mobile cameras and computing devices (Philips *et al.,* 2007; Vindasius, 2008) to facilitate cross-functional collaboration. Unlike email and bulletin boards, Collaborative Work Environments can provide support for synchronous activities, and can provide real-time support for the sharing of visual artifacts, unlike telephone conference facilities (Churchill & Snowdon, 1998). In this chapter a 'Collaborative Work Environment' is defined as:

A forum, which is specifically created to integrate people, processes, technology and facility for improved cross-functional and virtual collaboration, learning and high quality decision-making (Guldemond, 2011, p. 23).

A Collaborative Work Environment in the upstream petroleum industry can consist of (a) a Field office (located onshore, or offshore); (b) a Collaboration Center (main office, located onshore), and; (c) Service Companies. The main emphasis of this research is on the Field office and Collaboration Center, where both formal and informal collaboration takes place. CWEs are assumed to allow people to work collaboratively regardless of distance, making better decisions, faster, thereby enabling enhanced productivity and delivering operational performance improvements (Edwards, Saunders & Moore-Cernoch, 2006). CWEs aim to increase the quality of: cross-functional collaboration, virtual collaboration, and decision-making (Guldemond, 2011).

These changing work environments make strong demands on teamwork and learning. Teamwork in the Collaborative Work Environments has to cope with two important aspects: (1) Multiple locations (both on site and at distance, without the possibility of collocated face-to-face interaction); and (2) Multiple disciplines (people with different functional backgrounds).

OBSERVED CHALLENGES IN THE COLLABORATIVE WORK ENVIRONMENT

Business Process: Different Control Loops Combined

The implementation of Smart Oil Fields changes the way people work. In our research, the focus was on task complexity and task interdependence as critical task characteristics. As for task complexity, three forms were distinguished: (a) the amount of information involved in a task; (b) the internal consistency of this information; and (c) the variability and diversity of information. Regarding the amount of information involved in a task, a high volume of information goes through the team and executing the tasks is time-consuming. Regarding the internal consistency of the information, respondents of all three locations reported that devices don't provide the right data. A consequence is that it becomes more difficult to understand the behavior of the reservoir. Quality of decision-making will of course be influenced by unreliable data. Variability and diversity of information were also high due to the use of different computer programs and formats, and a great variety of activities, like fixing broken down pumps, compressors, coolers, and separators.

For task interdependence, a distinction was made between: (a) cross-functional collaboration and virtual collaboration, and; (b) short-term and long-term objectives (related to the control loops). The effectiveness of cross-functional collaboration and virtual collaboration depended on the timeframe of the objectives. Cross-functional collaboration and virtual collaboration was going well, when all staff members in the CWE were focusing on achieving short-term objectives (i.e. aligning the Real-Time Operations and Production Optimization control loops). If staff members in the CWE were focusing on aligning short-term (i.e. aligning the Real-Time Operations and Production Optimization control loops) with long-term

objectives (i.e. the Well & Reservoir Management control loop), difficulties in collaboration between staff members became apparent.

Figure 3 represents observed collaboration challenges in the Collaborative Work Environments of the three cases. The figure shows three disciplines (Operations, Engineering and Petroleum Engineering) with a few functions within these disciplines. The Operations' discipline primarily focuses on goals related to the Real-Time Operations and Production Optimization control loops. The Petroleum Engineering discipline primarily focuses on goals related to the Well & Reservoir Management control loop.

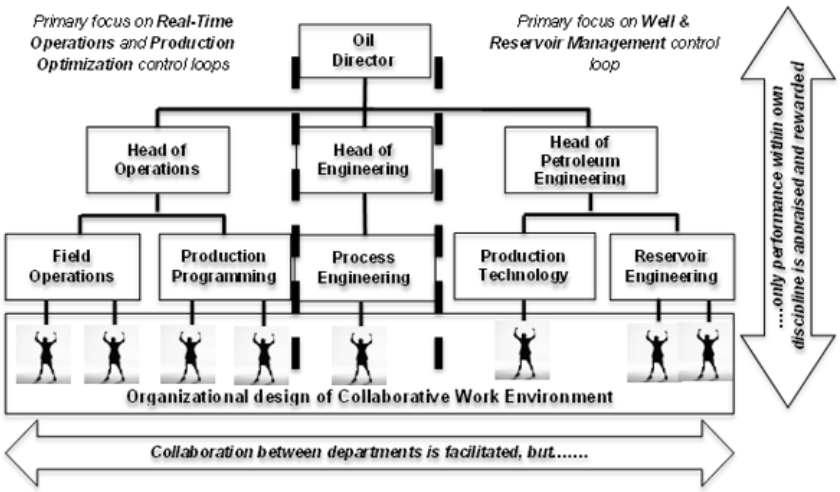
Organizational Structure: Aligning the Organizational Structure of the Operating Unit and Collaborative Work Environment

Smart Oil Fields work practices are largely determined at the production location level (Operating Unit), since these are the autonomous organizational bodies of most upstream oil companies (CERA, 2006). Collaborative Work Environments do not cover the Operating Unit as a whole, but are a part of the Operating Unit. Therefore, insights were needed into the organizational structure of the Operating Unit.

At the end of the 1990s/beginning of the 2000s, Operating Units in our research cases had 'Asset-based structure' (i.e. process-based structure) in place. Since then, however, they have changed from a 'Process-based structure' (with a focus on executing processes) to a 'Functional structure' or 'Functional-based matrix structure' (with a focus on developing functional specialization). This change was motivated by concerns about the technical quality of work. In the process-based structure no one is specifically responsible for long-turn technical skill development, whereas the functional structure tends to support in-depth skill development to a much higher degree (cf. Anand & Daft, 2007; Duncan, 1979; Hagist, 1994; Treat *et al.,* 1994). In fact, the organizational structures of the Operating Units in cases A and B had an emphasis on a functional structure, yet also showed characteristics of a process-based structure. In case C, the organizational structure of the Operating Unit was functional.

As for the CWE, a process dimension was introduced in its structure, based on 'process ele-

Figure 3. Observed collaboration challenges in the collaborative work environment



ments of control loops', but the functional lines of the Operating Unit remained predominant in determining reporting lines. Operating Units in case A en B installed complex horizontal coordination mechanisms (integrator roles, integrating departments and matrix organizations) in order to facilitate communications between personnel from the functional Operations and Petroleum Engineering departments. In a more limited setting, the Operating Unit in case C dealt with this coordination problem by using direct contact (mutual adjustment).

Competencies: Different Levels of Competencies

It was important to find out whether staff in the organization had the competencies required to work in a manner consistent with the goals envisaged for the CWE. The basic distinction by Hertel, Konradt & Voss (2006) between competencies for cross-functional teams (taskwork-related and teamwork-related competencies), and competencies for virtual teams (telecooperation-related competencies) was used. In cases A and B, respondents emphasized a large gap in the level of taskwork-related (i.e. technical) competencies between staff located at the collaboration center (onshore) and staff at the production location (onshore or offshore). Taskwork-related competencies at the collaboration center were considered of a high level, whereas at the production location they were seen as insufficient. This large gap in taskwork-related competencies between staff located at the two different locations was considered as an obstacle for effective collaboration in the CWE. In case C, a large gap in taskwork-related competencies between the two locations was not reported. In general, respondents believed teamwork-related competencies had improved by working in the CWE. Being in close proximity of each other, made discussing issues and making decisions in the CWE easier than before the CWE.

Referring to competencies for virtual collaboration, face-to-face contact (by using videoconferencing) resulted in more accountability between geographically dispersed members. Before using videoconferencing, CWE members were not able to see each other's facial expressions. By observing one's facial expression trust between these members increased.

RECOMMENDATIONS

In order to improve collaboration between the departments within the Collaborative Work Environment, recommendations for the business process, competencies and organizational structure are formulated.

Business Process: Start with Integrating the Operations' Loops

In our research, we observed that by integrating the Real-Time Operations and Production Optimization control loops the least organizational design challenges are caused, and in accordance required the least complex horizontal coordination mechanisms. It is therefore recommendable to start by integrating control loops for the short (Real-Time Operations) and medium terms (Production Optimization), followed by the integration of the control loops with the medium (Production Optimization) and long terms (Well & Reservoir Management). This is referred to as adopting a 'bottom-up approach' (De Sitter, Den Hertog & Dankbaar, 1997). The first recommendation is formulated as follows: *Start with the short-term control loop and over time integrate longer term control loops in the activities of the CWE.*

In Figure 4, the four control loops as distinguished by the upstream petroleum industry were presented. The longer the timeframe of the control loops, the more goals of different disciplines differ (i.e. differentiation of goal interdependence). When adding the first recommendation to Figure 4, the following representation can be made.

Organizational Structure: Make Matrix Structures More Effective

Despite being attractive on paper, the matrix organization is hard to manage (Nadler & Tushman, 1997), as we observed in two of our cases (cases A and B).

To make matrix organizations more effective, several approaches are suggested in the literature. Two of these approaches are: *(1) Careful definition of organizational roles and responsibilities,* and; *(2) Creation of appropriate management systems to support the matrix organization* (Galbraith, 2009; Knight, 1976).

Careful definition of organizational roles and responsibilities. The lack of clarity on roles and responsibilities is one of the underlying reasons for conflicts in the matrix organization (Galbraith, 2009; Goold & Campbell, 2003). A typical formulation of roles in the matrix organization is that the process manager decides what should be done, when and at what cost, while the functional manager decides who should do it and how (Knight, 1976, p. 127). In a CWE with a focus on Well & Reservoir Management, the WRM Team Leader decides then what should be done, when and at what cost, while the functional managers of the disciplines decide who should do it and how. After the organizational structure has been designed and people have been given their new roles, a process of defining roles and responsibilities begins. A useful tool for implementing matrix organizations is the responsibility chart (Galbraith, 2009). Figure 5 provides an example of a responsibility chart in the upstream petroleum industry.

The roles are represented in the (vertical) columns. The key decisions executed by these roles are represented as (horizontal) rows (cf. Galbraith, 2009). An (R) is given for a person who is responsible for making a decision. If a person must approve a decision, it is given an (A). An (C) is provided in case mutual agreement between two persons needs to be established. If a person needs to be informed, an (I) is given. People who have no formal role with regard to the decision (to be made), an (X) is provided (Galbraith, 2009).

Creation of appropriate management systems to support the matrix organization. The lack of having dual systems for accounting/budgeting, control, roles, evaluation and rewards (Knight, 1976; Kolodny, 1979; Lawrence, Kolodny & Davis, 1977; Nadler & Tushman, 1997) in place, results in a matrix organization that cannot structure and internalize the multiple and conflicting priorities (Knight, 1976). For example, a formal reward system must refer to two components: (1) the types of performance that are required to facilitate the strategy and the behaviors underlying that performance, and (2) the performance management system process that generates this information to measure these behaviors (Galbraith, 2009, p. 191).

Competencies: Importance of Soft Skills

The large gap in the level of technical competencies between Onshore Headquarters and Offshore Operations complicates the collaboration between the geographically dispersed locations. Clear instructions and procedures can bridge the knowledge gap between staff located Onshore and Offshore. Training programs were made available (containing all the Smart Oil Fields elements, like technical, processes, etc.), to ensure that the required competencies would be available (Guldemond, 2011). However, according to one of the respondents there are no specific trainings (on the behavioral part) for the Collaborative Work Environment given. This new way of working requires an emphasis on different behavior expected in the CWEs. Training in 'soft skills' can facilitate teamwork between the geographically dispersed locations. As for required competencies for virtual collaboration, there is a lack of knowledge on how to use the IT-tools for virtual collaboration, as one respondent observed. Both awareness of

Figure 4. Recommendation for the integration of control loops in the design of the CWE (Guldemond, 2011)

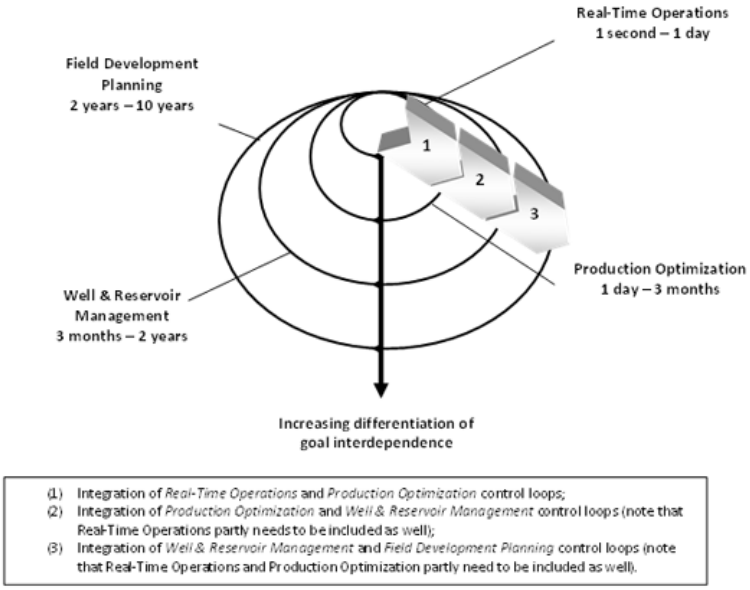


Figure 5. An example of a responsibility chart in the upstream petroleum industry (Guldemond, 2011)

Roles / Decisions	Production Programmer	Geologist	Process Engineer	Asset Manager	WRM Team Leader	Offshore Operations
Monitor Production and Well Performance	R	C	I	I	C	A
Analyze, Update & Generate Options	I	X	X	C	R	I
Manage Dynamic Opportunity Register	A	I	I	X	R	I
Plan Well Work Requests	C	X	R	X	C	A
Gather Data	R	C	I	X	A	A
Execute Optimization Activities	C	X	I	I	A	R

R = Responsible I = Inform
A = Approve X = No Formal Role
C = Consult

the importance and the possibilities of using the IT-tools can enhance virtual collaboration, for example a Smart Board can easily transfer graphics from one location to another.

FUTURE RESEARCH DIRECTIONS

In this research, a Collaborative Work Environment in a Smart Oil Field (social phenomenon) at an Operating Unit of an upstream oil company (context) was considered as a 'case'. Our case study research included three cases of a major oil company. Multiple cases have higher external validity compared to single cases (Eisenhardt & Graebner, 2007; Voss, Tsikriktsis & Frohlich, 2002). Although this major oil company is considered as an early adopter of the CWE concept in the upstream petroleum industry (Vindasius, 2008), a limitation of our case study design is that we were not able to include Operating Units of other upstream oil companies. As a result, it is difficult to generalize our findings from one upstream oil company to the upstream petroleum industry as a whole. This limits the external validity of our study. On the other hand, this major oil company has a decentralized organizational structure (cf. Grant & Cibin, 1996), which provided room for variety between the cases. Two of the Operating Units (cases A and B) consisted of joint ventures between the major oil company and a national (state-owned) oil company, which led to specific requirements concerning the use of local human resources. From that perspective the specific company is less relevant than the context of ownership and the focus of CWE.

A direction for further research is to include a sample with two types of Operating Units: (a) Two Operating Units with a joint venture structure, and (b) two Operating Units which have one full owner. Within each of these two types of Operating Units, one CWE should focus on Operations (by integrating the Real-Time Operations and Production Optimization control loops), and one should focus on Well & Reservoir Management (by integrating the Production Optimization and Well & Reservoir Management control loops). The influence of the CWE focus on organizational structure could be measured that way. Further research should include both perspectives of staff located at the collaboration center (onshore) and at the production location (onshore or offshore).

CONCLUSION

In the upstream petroleum industry there is ongoing debate whether the most value of Smart Oil Fields implementation lies in greenfield or brownfield assets (cf. Feineman, 2009; Robson, 2004) and on which of the control loops (cf. Philips *et al.,* 2007). So far, most oil companies started to implement Smart Oil Fields concepts into their brownfield assets, focusing on Well and Reservoir Management. The business case for large investment in brownfield assets is not always clear (Gerrard, McCabe & Beck, 2010). All of the oil fields in our cases were at the maturation stage (brownfields). As oil fields mature, costs are increasing for producing a barrel of oil (Gazi *et al.,* 1995). High investments in technology are required at the maturation stage (Morris & Lafitte, 1991). The lack of maintenance on wells and facilities was reported regularly, as a cause that devices don't provide the right data. A consequence is that it becomes more difficult to understand the behavior of the reservoir, as several respondents noted. In cases A and B, the Operating Unit decided to focus on Well & Reservoir Management, by integrating the Production Optimization and Well and Reservoir Management control loops. In case C, the Operating Unit decided to focus on Operations, by integrating the Real-Time Operations and Production Optimization control loops. Regarding CWE objectives; in all of our cases, Operating Units decided to focus

on to improve: the quality of cross-functional collaboration, virtual collaboration and decision-making (except for case B, which did not focus on decision-making). In our case study research, we did not observe direct links between the objectives of Smart Oil Fields implementation on the one hand, and its organizational arrangements (structure) on the other.

Today, most oil companies have functional reporting lines in place (Chapman & Forbes, 2010), which constrain cross-functional collaborative behavior. Every functional department is trying to achieve its own functional goal (goal differentiation). Current performance appraisal appears not to reward cross-functional collaborative behavior in Smart Oil Fields (Lameda & Van den Berg, 2009). In the upstream petroleum industry there is a deeply rooted belief that by adopting a new way of working in the CWE, an oil company rarely needs to restructure its organization by simply bringing together the roles and functions as a CWE team (cf. Vindasius, 2008). As Vindasius (2008, p. 8) argues: "While role responsibilities may need to be modified or people's location moved, individuals can usually continue to report to their functional or discipline manager". In our cases, we found empirical support for this deeply rooted belief. Indeed, the creation of new organizational structures shows to be very difficult to accomplish within the upstream petroleum industry, however, is definitely necessary to realize the full potential of collaboration (Edwards, Mydland & Henriquez, 2010) in its Collaborative Work Environments. Slowly, but eventually, we are getting there!

REFERENCES

Adefulu, Y. (2010, March). *SPE-128713: Enhancing asset performance: How can the benefits of collaborative work environments be effectively measured?* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Anand, N., & Daft, R. L. (2007). What is the right organization design? *Organizational Dynamics*, *36*(4). doi:10.1016/j.orgdyn.2007.06.001

Babadagli, T. (2005, June), *SPE-93884: Mature field development – A review.* Paper presented at the SPE Europec/EAGE Annual Conference, Madrid, Spain.

Bartram, M. A., & Wood, T. (2009, May). *OTC-20006: Future vision: The next revolution in production operations.* Paper presented at the 2009 Offshore Technology Conference, Houston, Texas, USA.

Bayerl, P. S., Lauche, K., Badke-Schaub, P., & Sawaryn, S. (2008, February). *SPE-112104: Successful implementation of collaborative environments: Human factors and implications.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Benford, S., Greenhalgh, C., Rodden, T., & Pycock, J. (2001). Collaborative virtual environments. *Communications of the ACM*, *44*(7), 79–85. doi:10.1145/379300.379322

Brett, J. F. (2007). *Lessons from history: The value of competent people. Talent & Technology, 1(1)*. Society of Petroleum Engineers.

Brufau, A. (2008). The future of the oil market: The great investment challenge. In Brufau, A. (Ed.), *Oil, gas, energy: A plural view, a calm look*. Madrid, Spain: Estudios de Politica Exterior.

Cassells, E. (1999). Building a learning organization in the offshore oil industry. *Long Range Planning*, *32*(2), 245–252. doi:10.1016/S0024-6301(99)00023-0

CERA. (2006). *The digital oil field of the future: Making the transition from vision to implementation*. Cambridge, MA: Cambridge Energy Research Associates.

Chapman, A., & Forbes, P. (2010, March). *Smart oil and the development of the networked organisation.* SPE-128452, Presented at the SPE Intelligent Energy Conference and Exhibition held in Utrecht, The Netherlands.

Churchill, E. F., & Snowdon, D. (1998). Collaborative virtual environments: An introductory review of issues and systems. *Virtual Reality (Waltham Cross)*, *3*, 3–15. doi:10.1007/BF01409793

de Best, L., & Van den Berg, F. (2006, October). *SPE-103575: Smart fields – Making the most of our assets.* Paper presented at the SPE Russian Oil and Gas Technical Conference and Exhibition, Moscow, Russia.

de Sitter, L. U., den Hertog, J. F., & Dankbaar, B. (1997). From complex organizations with simple jobs to simple organizations with complex jobs. *Human Relations*, *50*(5), 497–534. doi:10.1177/001872679705000503

Duncan, R. (1979). What is the right organization structure? Decision tree analysis provides the answer. *Organizational Dynamics*, *7*(3), 59–80. doi:10.1016/0090-2616(79)90027-5

Edwards, T., Mydland, Ø., & Henriquez, A. (2010, March). *The art of intelligent energy (iE) – Insights and lessons learned from the application of iE*. SPE-128669. Paper presented at the SPE Intelligent Energy Conference, Utrecht, The Netherlands.

Edwards, T., Saunders, M., & Moore-Cernoch, K. (2006, April). *SPE-100113: Advanced collaborative environments in BP*. Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. doi:10.5465/AMJ.2007.24160888

Feineman, D. R. (2009, April). *SPE-122676: Realizing value from real time monitoring in Greenfield Assets.* Paper presented at the SPE Digital Energy Conference & Exhibition, Houston, Texas, U.S.A.

Galbraith, J. R. (2009). *Designing matrix organizations that actually work: How IBM, Procter & Gamble, and others design for success*. San Francisco, CA: Jossey-Bass.

Gazi, N. H., Hottman, W. E., Logan, J. L., & Verrett, R. C. (1995, March). *SPE-29793: Alliances and partnering: A new relationship between oil/gas producing companies and service companies*. Paper presented at the SPE Middle East Oil Show, Bahrain, U.A.E.

Gerrard, C. A., McCabe, H., & Beck, A. D. (2010, March). *SPE-127849: Installation and implementation of "Smart Fields Foundation" on a brown field asset, adding value without major capital investment*. Paper presented at the SPE Intelligent Energy Conference held in Utrecht, The Netherlands.

Gobeli, D. H., & Larson, E. W. (1986). Matrix management: More than a fad. *Engineering Management International*, *4*, 71–76. doi:10.1016/0167-5419(86)90009-8

Goold, M., & Campbell, A. (2003). Making matrix structures work: creating clarity on unit roles and responsibility. *European Management Journal*, *21*(3), 351–363. doi:10.1016/S0263-2373(03)00048-3

Grant, R. M., & Cibin, R. (1996). Strategy, structure and market turbulence: The international oil majors, 1970 – 1991. *Scandinavian Journal of Management*, *12*(2), 165–188. doi:10.1016/0956-5221(95)00031-3

Guldemond, E. (2011). *Collaborative work environments in smart oil fields*. PhD thesis, Radboud University Nijmegen, The Netherlands.

Guldemond, E., & ten Have, K. (2008, February). *SPE-112173 group mental models in collaborative work environments*. Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Amsterdam, The Netherlands.

Hagist, P. W. (1994). *SPE-28358: The conversion to team based organizations.* Paper presented at the 69th Annual Technical Conference and Exhibition held in New Orleans, LA, U.S.A.

Heaney, M., & Davidson, J. (2006, April). *SPE-99885: Beyond the big crew change, dumbing down or getting smarter?* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Henderson, G. (2005, May). *OTC-17727: The impact of digital technologies on the global Shell EP business.* Paper presented at the 2005 Offshore Technology Conference, Houston, Texas, U.S.A.

Hertel, G., Konradt, U., & Voss, K. (2006). Competencies for virtual teamwork: Development and validation of a web- based selection tool for members of distributed teams. *European Journal of Work and Organizational Psychology*, *15*(4), 477–504. doi:10.1080/13594320600908187

Hickman, A., Guidry, A., & Seaton, S. (2008, February). *112141-MS: Real-time collaboration – efficient problem solving and extending resources.* Paper Presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Hyne, N. J. (2001). *Nontechnical guide to petroleum geology, exploration, drilling, and production*. Tulsa, OK: PennWell Corporation.

Knight, K. (1976). Matrix organization: A review. *Journal of Management Studies*, *13*(2), 111–130. doi:10.1111/j.1467-6486.1976.tb00528.x

Knoppe, R., & Holloway, S. (2008, February). *SPE-112060: The application of knowledge and continuous learning to the implementation of collaborative work environments at Shell.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Kolodny, H. F. (1979). Evolution to a matrix organization. *Academy of Management Review*, *4*(4), 543–553.

Lameda, R., & Van den Berg, F. (2009, April). *SPE-123352: Integration is about people.* Paper presented at the SPE Digital Energy Conference & Exhibition, held in Houston, U.S.A. Lawrence, P. R., Kolodny, H. F., & Davis, S. M. (1977). The human side of the matrix. *Organizational Dynamics*, *6*(1), 43–61.

Miskimins, J. L. (2009). *Design and life-control loop considerations for unconventional-reservoir wells* (pp. 353–359). SPE Production & Operations.

Morris, R. L., & Lafitte, F. (1991, April). *SPE-22036: Consolidating and managing a mature portfolio.* Paper presented at the SPE Hydrocarbon Economics and Evaluation Symposium, Dallas, Texas.

Murray, R., Edwards, C., Gibbons, K., Jakeman, S., & Jonge, G. de, Kimminau, S., … Vachon, G. (2006, April). *SPE-100024: Making our mature fields smarter – An industry-wide position.* Paper presented at the SPE Intelligent Energy and Exhibition, Amsterdam, The Netherlands

Nadler, D. A., & Tushman, M. L. (1997). *Competing by design: The power of organizational architecture*. New York, NY: Oxford University Press.

Philips, I. C., Critchley, C., Shaw, P., & Thomas, J. (2007, April). *SPE-106982: Deployment of advanced collaborative environments at scale in the North Sea operations.* Paper presented at the 2007 SPE Digital Energy Conference and Exhibition held in Houston, Texas, U.S.A.

Popham, M., & Edwards, T. (2009, April). *SPE-123096: What lessons can digital oil field practitioners learn from defence initiatives such as network enabled capability?* Paper presented at the SPE Digital Energy Conference & Exhibition held in Houston, Texas, U.S.A.

Rawdon, J. C. (2003, March). *SPE-80948: Collaboration in knowledge sharing.* Paper presented at the SPE Production and Operations Symposium held in Oklahoma City, Oklahoma, U.S.A.

Robson, S. (2004, October). *SPE-88582: Alliancing and partnerships: What we have learned and where we are going.* Paper presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition, Perth, Australia.

Saggaf, M. M. (2008). A vision for future upstream petroleum technologies. *Journal of Petroleum Technology*, *53-55*, 94–98.

Tealdi, L., Kreft, E., & Donachie, J. M. (2006, April). *SPE-99924: Developing young exploration and production professionals to solve the "big crew change".* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Treat, J. E. (Ed.). (1994). *Creating the high performance international petroleum company: Dinosaurs can fly*. Tulsa, Oklahoma: PennWell.

Tye, B. (2010, March), *SPE-129112: Unconventional hydrocarbons: Intelligent integration and operation.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

van den Berg, F. (2007, April), *SPE-108206: Smart fields – Optimizing existing fields*. Paper presented at the SPE Digital Energy Conference and Exhibition held in Houston, Texas, U.S.A.

Vindasius, J. (2008, February). *SPE-112218: The integrated collaboration environment as a platform for new ways of working: Lessons learned from recent projects*. Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, *22*(2), 195–219. doi:10.1108/01443570210414329

Yawanarajah, S., Williams, J., Carrell, K., Webb, T., & Cox, M. (2008, November). *SPE-118128: Improving life control loop project delivery through better decision-making under uncertainty.* Paper presented at the SPE 2008 Abu Dhabi International Petroleum Exhibition and Conference, Abu Dhabi, U.A.E.

ADDITIONAL READING

Arvidsson, N. (2009). Exploring tensions in projectified matrix organisations. *Scandinavian Journal of Management*, *25*, 97–107. doi:10.1016/j.scaman.2008.09.002

Baddour, J. W. (1997). The international petroleum industry: Competition, structural change and allocation of oil surplus. *Energy Policy*, *25*(2), 143–157. doi:10.1016/S0301-4215(96)00117-6

Bauquis, P. R., & Bauquis, E. (2005). *Understanding the future: Oil and natural gas*. Strasbourg, France: Editions Hirle.

Brown, C. V. (1999). Horizontal mechanisms under differing IS organization contexts. *Management Information Systems Quarterly*, *23*(3), 421–454. doi:10.2307/249470

CERA. (2010). *Toward the predictive organization*. Cambridge, MA: Cambridge Energy Research Associates.

Chapman, A., & Forbes, P. (2010, March). *SPE-128452: Smart oil and the development of the networked organisation.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Collier, T. S. (1992, March). *SPE-00023993: Oil industry decision making: A focused approach.* Paper presented at the SPE Permian Basin Oil and Gas Recovery Conference, Midland, Texas, U.S.A.

Crompton, J., & Gilman, H. (2010, March). *SPE-127715: The future of integrated operations.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Ford, R. C., & Randolph, W. A. (1992). Cross-functional structures: A review and integration of matrix organization and project management. *Journal of Management*, *18*(2), 267–294. doi:10.1177/014920639201800204

Galbraith, J. R. (1971). Matrix organization designs: How to combine functional and project forms. *Business Horizons*, (1): 29–40. doi:10.1016/0007-6813(71)90037-1

Galbraith, J. R. (1973). *Designing complex organizations*. Reading, MA: Addison- Wesley.

Galbraith, J. R. (1974). Organization design: An information processing view. *Interfaces*, *4*(3), 28–36. doi:10.1287/inte.4.3.28

Goode, P. (2005, May). *17728-MS: Progress towards the digital oilfield: Evolution or revolution?* Paper presented at the Offshore Technology Conference held in Houston, Texas, U.S.A.

Gryskiewicz, K., & Knoppe, R. (2009, April). *SPE-123202: Evolution of collaborative work environments – Are we ready for it?* Paper presented at the 2009 SPE Digital Energy Conference & Exhibition, Houston, Texas, U.S.A.

Guldemond, E., ten Have, K., & Knoppe, R. (2010, March). *SPE-128274: Organizational structures in collaborative work environments: The return of the matrix?* Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Utrecht, The Netherlands

Harris, M., & Raviv, A. (2002). Organization design. *Management Science*, *48*(7), 852–865. doi:10.1287/mnsc.48.7.852.2821

Henriquez, A., Fjaertoft, I., Yttredal, O., & Johnsen, C. (2008, February). *SPE-111470: Enablers for the successful implementation of intelligent energy: The Statoil case.* Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Amsterdam, The Netherlands

Hultzsch, P., Lake, L. W., & Gilbert, R. B. (2007, April). *SPE-107704: Decision and risk analysis through the life of the field.* Paper presented at the 2007 SPE Hydrocarbon Economics and Evaluation Symposium held in Dallas, Texas, U.S.A

Knabe, S., Rabin, P., & McGrath, T. (2002, September). *SPE-77734: Implementing successful mergers in the oil and gas industry.* Paper presented at the SPE Annual Technical Conference and Exhibition held in San Antonio, Texas, U.S.A.

Landgren, K., & Sood, S. (2006, April). *SPE-99485: Challenges in integrated operations centers.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

LeBas, R., & Edwards, W. J. (2007, November). *SPE 109820: From the what can I do for you to the what can you do for me generation: The disconnect between the establishment and the youth culture in the oil industry.* Paper presented at the SPE Annual Technical Conference and Exhibition 2007, Anaheim, California, U.S.A.

Mahroos, F. A. (2005, March). *SPE-93708: Future challenges for producing Middle east oil fields during maturation stage.* Paper presented at the 14th SPE Middle East Oil & Gas Show and Conference held in Bahrain International Exhibition Centre, Kingdom of Bahrain.

Mahroos, F. A., & Zubari, H. (2009, March). *SPE-120214: Challenges of producing Middle East oil fields during the maturation stage – A paradigm shift.* Paper presented at the 2009 SPE Middle East Oil & Gas Show and Conference, Kingdom of Bahrain.

Moisés, G. V., Rolim, T. A., & Formigli, J. M. (2008, February). *SPE-112153: GeDIg: Petrobras corporate program for digital integrated field management.* Paper presented at the 2008 SPE Intelligent Energy Conference and Exhibition Amsterdam, The Netherlands.

Nadler, D. A., & Tushman, M. L. (1988). *Strategic organization design: Concepts, tools, & processes*. London, UK: Scott, Foresman and Company.

Paylow, K., Hickman, A., & Zappa, D. (2006, April). *SPE-99898: Identify future leaders through knowledge management.* Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Amsterdam, The Netherlands.

Potters, H., & Kapteijn, P. (2005, November). *IPTC-11039: Reservoir surveillance and smart fields.* Paper presented at the International Petroleum Technology Conference held in Doha, Qatar.

Rajan, S., & Krome, J. D. (2008, September). *SPE-115030: Intelligent oil field of the future: Will the future be too late?* Paper presented at the 2008 SPE Annual Technical Conference and Exhibition, Denver, Colorado, U.S.A.

Roland, S., Yttredal, O., & Moldskred, I. O. (2008, February). *SPE-112251-MS: Successful interaction between people, technology and organization – A prerequisite for harvesting the full potentials from integrated operations.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Russo, E. E. R., Amoroso, J. C., & Rolim, T. A. (2010, March). *SPE-128675: Benefits quantification and change management in Petrobras corporate program for digital integrated field management (GeDlg).* Paper presented at the 2010 SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Taylor, D., & Fosse, K. (2006, April). *SPE-100704: Collaborative decision making in operations-centre environments.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Thompson, A. M. (2008, February). *SPE-112017: Collaborative working in the oil and gas production support industry*. Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Womack, J. P., & Jones, D. T. (2003). *Lean thinking: Banish waste and create wealth in your corporation*. New York, NY: Free Press.

KEY TERMS AND DEFINITIONS

Collaborative Work Environment: A forum, which is specifically created to integrate people, processes, technology and facility for improved cross-functional and virtual collaboration, learning and high quality decision-making.

Organizational Design: The allocation of resources and people to a specified mission or purpose and the structuring of these resources to achieve the mission.

Smart Oil Field: A context where the combination of (a) hardware and systems; (b) data and standards, and; (c) people and skills, enables the organization to access difficult oil fields, and to provide it with real time data of the actual situation of petroleum production and reserve quantity.

ENDNOTES

1 In the petroleum industry two main domains are distinguished: upstream and downstream: "Upstream' includes exploration and production; 'downstream' includes transportation (including pipelines), refining and marketing" (Grant & Cibin, 1996, p. 171).

2 Hyne (2001) defines 'recovery factor' as "the percentage of OIP [oil in place] or GIP [gas in Place] that the reservoir will produce" (p. 431).

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Chapter 5
Connecting Worlds through Self-Synchronization and Boundary Spanning:
Crossing Boundaries in Virtual Teams

Cathrine Filstad
BI Norwegian Business School, Norway

Vidar Hepsø
Norwegian University of Science and Technology (NTNU), Norway

Kari Skarholt
SINTEF, Norway

ABSTRACT

This chapter investigates knowledge sharing in collaborative work. Through two empirical studies of personnel working offshore and onshore in an oil company, the authors address the role of self-synchronization and boundary spanning as practices for improving collaboration in integrated operations. They focus on the following enabling capabilities for collaborative work: management, knowledge sharing, trust, shared situational awareness, transparency, and information and communication technology. This chapter is more concerned with the people, process, and governance aspects of a capability development process for integrated operations. The authors are especially interested in how self-synchronization and boundary-spanning practices emerge in a dynamic relationship with the identified enabling capabilities. Self-synchronization and boundary-spanning practices influence the enabling capabilities and vice versa. In the end the improved practices and the enabling capabilities are so intermingled that it becomes difficult to describe causal relations and effects.

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INTRODUCTION

Enabling knowledge transfer through collaboration across boundaries is essential to globalization and innovation (Nonaka and Takeuchi, 1995; von Krogh, Ichijo, and Nonaka, 2000). Consequently, virtual teams have become more common (Kotlarsky and Oshri, 2005), recognizing the importance of virtual collaboration across boundaries. Collaboration of knowledge sharing through practices are made possible using effective information and communication technology (Kasper-Fuehrer et al., 2001; Powell et al., 2004). Emphasis is on viewing boundaries as knowledge-creating artifacts and powerful connectors that drive innovation and learning (Carlile, 2002, 2004). However, there are challenges associated with knowledge sharing across such boundaries, involving advanced collaboration technologies and limited face-to-face interaction. Trust in both colleagues and technologies are needed, because collaborative work rests on a shared understanding of each other's position and contribution (Ardichvili et al., 2003).

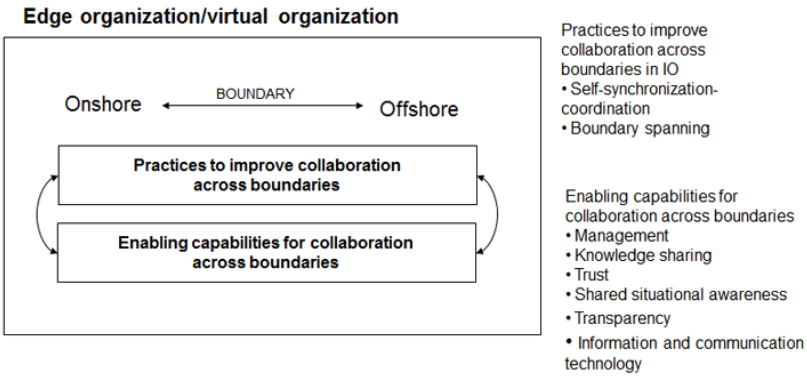
Knowledge sharing in integrated operations across boundaries occurs within an existing or emerging governance structure, where colleagues collaborate in virtual teams, where knowing how to perform professionally is key for solving common tasks. Recognizing knowledge as knowing enables us to investigate knowledge sharing and collaboration more fruitfully. Knowing has a special meaning when solving practical work issues because knowing emphasizes the context-specific and the unique or different requirements needed for effective collaboration across boundaries (Tsoukas, 2005; Gherardi and Nicolini, 2000; Brown and Duguid, 1991; Lave and Wenger, 1991; Blackler, 2004). Knowing is a communication process (Kasper-Fuehrer et al., 2001: 239) and involves interactive processes that affect, monitor, and guide members' actions and attitudes in their interactions with one another. It is within this approach to knowing we explore knowledge sharing.

To address knowledge sharing in virtual teams, several enabling capabilities for collaboration across boundaries have been recognized. Challenges involve creating trust among colleagues, trusting, and utilizing the technological infrastructure. Also, sharing knowledge is challenging without a sufficiently shared situational awareness. Practice must also be organized and virtual collaborative work managed. In what follows we make explicit the role of self-synchronization and boundary spanning in collaboration and how they affect knowledge sharing. Thus, self-synchronization and boundary spanning are identified as practices to improve collaboration across boundaries and critical to address in capability development work that must focus on people, process and governance issues.

The purpose of this chapter is to examine collaborative work across boundaries; the work practices of integrated operations that are instrumental in developing the necessary people, process and governance capabilities. The unit of analysis is offshore and onshore personnel in an oil and gas company. We ask how self-synchronization and boundary spanning interact with a number of enabling capabilities to improve collaboration across boundaries. Our contribution is first and foremost empirical, analyzing the practices of collaborative work across boundaries in relation to self-synchronization and boundary spanning, and identifying enabling capabilities for achieving knowledge sharing across boundaries in virtual/distributed teams.

Figure 1 gives an overview of two practices and several enabling capabilities that are believed to effect collaboration across boundaries in IO. It outlines the practices of self-synchronization and boundary spanning as vital for improving collaborative work. This practice is taking place within a number of enabling capabilities. However, these two processes might be interconnected through daily work in the sense that they mutually influence each other. This indicates that self-synchronization practice can improve

Figure 1. Practices and enabling capabilities for collaboration across boundaries



the conditions for knowledge sharing and good conditions for knowledge sharing might result in improved self-synchronization practice.

First, we describe the characteristics of self-synchronization and boundary spanning in edge organizations. Then enabling capabilities such as management, knowledge sharing, trust, shared situational awareness and transparency are discussed as possible enabling capabilities for collaborative work. We acknowledge that there are people, process, governance and technology elements in all such configurations of enabling capabilities. However, for heuristic reasons we focus on the people and governance aspects in this chapter, even though the role of information and communication technology is a key enabling capability across the cases in the chapter.

EDGE ORGANIZATIONS

The oil company we have studied resembles an edge organization. An edge organization is a subcategory of a high-reliability organization (Perrow, 1999; Weick & Sutcliffe, 2001), and it assumes a widespread sharing of information and a broad distribution of decision rights. Edge organizations consist of smaller, domain-focused social practices that inhabit relevant knowledge and capabilities. Through practice, they form richly linked and frequently interacting clusters that allow them to exchange information. They permit the development of shared situation awareness through collaboration in order to synchronize their plans and undertake synergistic actions (Alberts & Hayes, 2003). Peer-to-peer relationships dominate, reducing the need for middle managers to constrain and control. An edge organization's hierarchical control structure, in many respects, uncouples command from control. Command is involved in setting the initial conditions and providing overall intent. Control is not a function of command but an emergent property; it is a function of the initial conditions – of the environment and of the nature of the challenges to be undertaken.

It is the division of work across spatial, temporal, and knowledge boundaries that sets the scene for collaboration across boundaries in integrated operations. However, these boundaries separate groups that must collaborate. Therefore, these boundaries must be bridged. Thus, in what follows we describe how practices of self-synchronization and boundary spanning and their enablers might bridge boundaries in distributed collaborative work.

Self-Synchronization and the Synchronization Challenge

Self-synchronization addresses new ways of distributing tasks and problem solving. Synchronization deviates from a more traditional hierarchical coordination. In self-synchronization, distribution of tasks is done to a larger degree between peers. Self-synchronization is achieved by the means of all members having peripheral awareness of priority tasks and resources.

Alberts and Hayes (2003) set up some assumptions or enablers for self-synchronization. First, they argue that self-synchronization exists in a setting with clear management intent, in order to avoid wasting resources and sub-optimization. The management function is not absent in a self-synchronized organization, but command and control become unbundled. Management is needed to create the initial conditions and provide an overall congruent strategic intent. Management leads, but does not dictate the details of the work of employees. Second, to enable self-synchronization, competence at all organizational levels is necessary. Individuals and groups must have the capacity, information, and means to make efficient decisions. However, this condition requires trust and a willingness to share knowledge. Third, self-synchronization presupposes that those participating in collaborative work share a sufficient understanding and awareness in situations including resource coordination between participants in response to situations as they arise (Alberts & Hayes, 2003).

Finally, there is an element of transparency for self-synchronization to work. The ability to learn from others and give feedback and input to peers presupposes that people and practices are visible. Knowledge sharing must involve communication of shared experience among participants in problem-solving activities (Ardichvili et al., 2003). Colleagues must also be comfortable participating in a computer-mediated world (Ardichvili et al., 2003). Information and communication technology is therefore an enabling capability in creating increased transparency and self-synchronization in integrated operation.

Self-synchronization is a strategy that grows out of the problem of synchronization, satisfying constraints on the arrangement of things and effects in time and space (Henderson 2011). Malone and Crowston (1994) defined coordination as the act of managing dependencies among activities. A dependency represents a set of problems that must be managed by one or more coordination mechanisms in order to produce an effective (coordinated) process. Malone and Crowstone's coordination theory identified three types of dependencies. A flow dependency, where one activity produces or provides a resource that is consumed or used by another activity. The right resource at the right time and location will solve this. A sharing dependency, where a resource produced by one activity is used by more than one activity. This can be managed by addressing the issue of resource allocation. We follow Henderson (2011) when he argues that the third, a fit dependency is most important for our purpose. It arises when a resource consumed by one activity is produced by more than one activity. Fit dependency can be managed by ensuring that the outputs of the multiple producing activities fit together properly to create the single output required by the consuming activity.

Henderson (2011) argues that most coordination mechanisms that work for traditional fit dependencies will not work for synchronization problems. He shows that synchronization problems arise when there are constraints on the arrangement of multiple things and effects. Each activity involved in producing part of the overall arrangement must take into account the output of the other activities that contribute to this arrangement. Henderson argues how new technologies and trends like integrated operations may have the impact of turning what was a traditional fit dependency into a synchronization problem. Integrated operations is just one example where new technologies for remote collaboration encourage companies to make increasing use of distributed/

virtual teams and to create business processes that require tight integration across company or domain boundaries. His point is that when such change is introduced, existing coordination mechanisms, developed to manage traditional fit dependencies, will most likely lose their effectiveness. Managers used to treat emerging synchronization problems as fit dependencies need to develop the capability to identify which kind of problems they have and choose appropriate mechanisms for managing it.

Boundary Spanning

Recent work on boundary spanning has focused on the knowledge needed and the ability of agents to span multiple boundaries (Carlile, 2002, 2004; Cross et al., 2004; Levina and Vaast, 2005; Orlikowski, 2002; Pawlowski and Robey, 2004; Hepsø, 2008). Organizational knowledge in spanning boundaries is embedded as knowing (Orlikowski 2002) in practices producing or enacting knowledge as knowing (Levina et al. 2005).

The importance of boundary spanning will increase with the growth of synchronization challenges. Boundary-spanners-in-practice (Levina et al., 2005) are agents who engage in spanning, facilitate the sharing of knowledge by linking two or more groups of people separated by location, hierarchy, or function (Cross et al., 2004), formal and informally integrating, institutionalizing and coordinating collaborative work.

Knowledge sharing and trust are important enabling capabilities for boundary spanning, and challenging due to limited face-to face interaction (Jarvenpaa et al., 1998; Kasper-Fuehrer et al., 2001). Perceived commitment and creating a shared situational awareness of goals are often difficult when members are distributed (Hertel et al., 2004; Malhotra et al., 2007). Thus, swift trust means that individuals, mostly in temporary groups, make initial use of category-driven information processing to form stereotypical impressions of others (Meyerson et al., 1996; Kasper-Fuehrer et al., 2001; Jarvenpaa et al., 1998). It is typically related to strategic intent and coordination because it "simplifies" communication. Sharing knowledge and sensitive information inherently involves risk, while trust generates solidarity by fostering an atmosphere of conductive cooperation and sharing (Abrams et al. 2003; Lines et al. 2006). If trust exists in knowledge sharing activities as a consequence of self-synchronization and boundary spanning, much of the work a boundary spanner invests in monitoring and controlling others becomes less important (McEvily, 2003).

The Oil and Gas Industry: New Enabling Information and Communication Technologies

The last ten years have brought new enabling capabilities and practices that have eased collaboration across boundaries in the onshore and offshore oil industry in Norway. Some of these capabilities are associated with information and communication technology. First was the continuous development and increase of long distance IT transfer networks that transferred real-time data (video, audio, data control and steering, monitoring data, and 3D pictures/models). In conjunction with this trend was the evolution of the Internet, which provided new opportunities for information sharing and collaboration by teams across technical, organizational, and geographical borders. Individuals in different locations, working for different companies, could access and/or manipulate the same data at the same time. Standardization of telecommunication software/hardware platforms and data exchange formats eased the integration of data (OLF, 2005). A convergence of computing and telecommunications led to the development of collaboration tools/software like video-conferencing, Net-meeting, Smart boards, instant messaging, and 3D visualization that made cross-distance communication easier. This is key enabler that is important to understand the development of integrated operations.

METHODS

Data were collected in two cases in the largest oil company in Norway through in-depth interviews and ethnographic observations of employees working in cross-disciplinary virtual teams offshore and onshore. The first case presented is from a three-month pilot in 2005 (and includes two days of observations every week, a total of 20 full working days). In addition, participant observation was conducted in computer-supported collaboration rooms in Statoil assets for almost three years (40 days in 2006 and 20 days in 2007). In addition, 35 interviews were conducted with people working in these facilities over a period of two years. Also, offshore control room operators were observed during several shifts in 2008. The second case "IO at Kristin" was mainly conducted in 2007. Before this one of the authors conducted participatory observation of formal and informal meetings during the project phase in Kristin (2003–2004, for a total of four weeks) and later during operations (2006, for two months). In the "IO at Kristin project" in 2007 personnel in all offshore and onshore functions were interviewed, both onshore and onshore. These functions included onshore and offshore managers, offshore operators within all disciplines on the platform (electro, mechanic, automation, instrument, process, etc.), and onshore discipline experts (engineers). Sixty-nine interviews (including all three shift rotations offshore) were carried out. In addition important data was gathered via participatory observations. We participated in different formal meetings in the collaboration rooms both onshore and offshore, and observed the maintenance work of the operators out in the process plant.

CASE 1: BOUNDARY SPANNING IN PRODUCTION OPTIMIZATION

Production optimization as a collaboration practice addresses the short- and long-term control and optimization of oil and gas flows in a value chain. Oil and gas flow from a reservoir via offshore processing facilities and are exported to a market in the safest and most cost efficient way. This is a coordination-intensive process involving several professional disciplines. It includes boundaries with strong dependencies, reservoir management, well optimization, process optimization, production optimization, and logistics. These disciplines roughly correspond to the technical disciplines involved in production optimization. The offshore control room operators monitor technical systems and equipment, involving critical issues related to safety (like emergency and process shut-down alarms) and minute-to-minute production. Offshore control room operators operate the valves and the equipment that the onshore production engineers need to improve the performance of the wells. The offshore control room is an obligatory passage point for all changes in production settings. Production optimization is traditionally seen as a fit dependency that can be addressed with coordination, but due to practices emerging via integrated operations more synchronization challenges emerge.

As enabling capabilities for collaboration across boundaries the production engineer uses several computer-mediated systems to acquire status, predict output, and follow up well performance. There is a partial overlap in the IT systems used by control room operators and production engineers. A minimum level of shared situation awareness is enabled by these systems, related to both the state of the production process and the ongoing activities across disciplines. The job of the onshore production engineer is to follow up the performance of the wells and challenge the operating limits of the wells with a short- and long-term perspective.

In our study we focus on collaboration across the offshore–onshore boundary in IO, more specifically tasks that are undertaken by onshore production engineers and the offshore central control room (CCR) during a well test. Such well

tests are needed to estimate how much oil or gas a well produces. Since most wells produce into a co-mingled flow-line or have poor or malfunctioning instrumentation, identifying how much a well produces can be cumbersome. Still, the production engineer needs to know how much the well produces in order to plan future production. To obtain this information, physical action must be undertaken offshore. This means that the other wells on the co-mingled production line must be closed down and the well on test must be routed via a test separator. This test separator has measurement equipment that estimates the real production flow of the well, resulting in a more precise calculation of the production performance. However, onshore production engineers cannot do this themselves. They have to trust that the offshore operators perform the task correctly. Execution of a well test is the domain of offshore control room operators and it must be coordinated with other ongoing offshore tasks. Well tests are planned and executed according to a pre-defined schedule and an existing division of labour. The onshore production engineers plan the sequence of the well tests and the offshore control room operators execute the plan. A production and injection plan, shared via the IT systems, describes which wells should be tested within a specific period of time. The procedure for doing the well testing is also well known both onshore and offshore. However, each well test tends to be slightly different because it will depend upon the contingencies of work activities, since it crosses boundaries into other disciplines. The offshore CCR operators also have other priorities, since the operators' key activity is to maintain a stable situation in the offshore process facility. Thus, they may re-schedule activities to be able to undertake the well test. A troublesome situation out in the plant might require the operator to handle this contingency first and postpone the testing. Usually, production optimization of onshore–offshore communication has elements of both swift trust and a more thorough, deeper type of trust. Since swift trust typically is related to strategic intent and coordination; both production engineers and control room operators must understand each other's role. Also, by trusting each other's competence, they enable to share knowledge for effective collaboration.

For example, one morning, an onshore production engineer looks into the production management system and wonders why the well tests that were planned yesterday evening were not executed. In order to find out why, the production engineer calls the offshore control room, presenting himself using his organizational abbreviation:

Hi, it's PETEK. I was wondering how the work with the well tests is going? Wells X-45 and X-36 were due for well tests yesterday evening but I don't see any figures in our system. Did something go wrong?

The usual way of approaching the CCR is not to use your personal name, even though you might know the person on the other side. It is the department or "function" of petroleum technology (PETEK) that makes the call – the organization that is responsible for the performance of the wells. The control room operator answers:

Sorry about this, but we had an unplanned shutdown yesterday. We had to spend our time getting the platform up and running again and had no time for the well test. We will do it after lunch, if we have time.

The production engineer who makes the call is co-located with two other production engineers who have a peripheral awareness of what is going on. One of the engineers says:

So John is back again; he can't be pushed. When I was offshore some weeks ago I had a long conversation with him. He is very hands-on in relation to what happens out in the facility and very unsure about the wells. Let's give him some time and see what happens.

Four hours pass and the production engineers do other things in between, but the well tests are needed to update the production prognosis. The production engineer asks his colleagues:

Should I call and enquire into what's happening with the well tests?

His colleague answers:

Do not call them now. It will soon be three o'clock and their scheduled break. It will upset them if you call them right now. I am on duty tonight and will wait until Hans has taken over. He will prioritize this when I call him and when things are getting less noisy [when the onshore people have gone home and there are fewer things happening].

The second production engineer's suggestion captures a lot of detailed understanding to make swift trust really work. It shows how the communication between professionals has a high degree of empathy or subtleness.

It depends very much upon the person as to how difficult it is to get in contact with them. I recognize that those I know well, offshore, are those I have travelled out with and talked to previously. I know that they have a private boat, a cottage in the mountains. I know the name of their dog, things like that. Then it is much easier to contact them, and therefore I also do that more often.

The production engineer explains why he suggested postponing the call:

We are dependent upon having a good long-term relationship with the offshore control room. If we are regarded as fools this will hit us in the head later. If we lose their trust we are in trouble.

In the offshore control room of another asset, PETEK called and the suggested well action was executed immediately. The offshore operator comments on the relationship with PETEK:

I can't say that I know the production engineers, but we have training sessions on the process control system before we go offshore and this helps us to get to know those that work onshore… It helps to get them offshore. When they sit together with us we learn much more about the wells.

The smooth way the production engineers reacted to the missing well test is an example of boundary spanning. It outlines the importance of trust in knowledge sharing and collaborative work. Engineers become vulnerable when they have to trust that offshore personnel will perform well tests. This becomes obvious when elaborating more on the practices of boundary spanning that are very linked to addressing synchronization challenges. Let us address what work is needed by the production engineer to verify the reliability of the data regarding how much a particular well produces. During the first days after a test, the production engineer can rely on the data. However, the older the well test data, the less a production engineer can trust them. The more the well test data are aggregated through networks of wells without knowing the changing performance of wells in between well tests, the more they will end up with aggregations that have large uncertainties (Hepsø, 2009). The production engineer knows this and therefore finds other ways of dealing with the data when the well test is no longer reliable. This is also an arena for boundary spanning. Various types of data are evaluated and checked by the production engineer and placed in proper contexts, based on a detailed understanding of the asset's wells. When finding the right information, the production engineer will know which people work together and will approach them to fill knowledge gaps that information systems, analysis, and data-sets cannot provide. When acquiring technical domain input in the asset environment, the important thing is to know which

people to trust and who knows what. This includes knowing the players in the game and facilitating collaboration via help, advice, or ideas. It means knowing how to approach the reservoir engineer to check out details related to the characteristics of the particular segment of the reservoir. In these knowledge sharing processes, knowing your colleagues' competences will be employed to deal with the contingencies and create necessary trust among colleagues.

We recognize how collaborative work onshore and offshore rests on trust to achieve knowledge sharing to enable boundary-spanning activities. But what about management as an enabling capability? We find that management provides the initial coordination conditions and the overall congruent strategic intent. This is also a strategy to deal with the synchronization challenge. It guides the development of shared situation awareness and performs more authoritative resource allocations when needed, as depicted by the line manager of the production engineers:

I cannot intervene in the daily work of my engineers. I verify and sign the production and injection plan and try to be "hands on" when they request my help. I support them by providing them with the resources they need. We have recently increased the number of production engineers from two to four and re-located them to a new collaboration room because we believe there is a high value potential in production optimization.

CASE 2: SELF-SYNCHRONIZATION WITH SHARED SITUATIONAL AWARENESS IN THE KRISTIN ASSET

Kristin is a new offshore installation with the newest IO collaboration technologies used to facilitate shared situation awareness between onshore and offshore staff. This is supported through the use of shared work arenas: continuous videoconferencing capabilities. It is argued that it is through these shared facilities that colleagues establish a high degree of knowledge about the artefacts, particularities, and history of the installation and a high degree of knowledge of the priorities of the installation (Næsje et al., 2009; Skarholt, et al., 2009).

An enabling capability for collaborative work at Kristin is an operational governance model that promotes a high degree of ownership of the tasks and also a high degree of transparency of work. This governance model co-exists with the business processes of the company. As one of the onshore managers argued concerning the Kristin organizational model:

We wanted to have a small organization with few people in each position. At the same time the crew should have competence and some basic skills in several disciplines so they are able to fill in for each other when situations develop.

A minimum level of transparency is critical for both the dynamics between functions (between operations, management, and technical support) and for the self-synchronization experienced between colleagues. Transparency is also a way to deal with the synchronisation challenge. This sort of transparency makes the connection between tasks and functions visible, as reported by a technician:

I am the only person on this shift that has special skills in this field, and the others know they must come to me to get the job done.

If a task is not completed it is easy to see who is responsible in a small organization. With a full-planning-execution loop in the work processes and a high level of transparency around task responsibility, the number of hand-offs is reduced and motivation is strengthened. Self-synchronization is achieved here via transparency. It reduces the need for management coordination and promotes a safe and reliable operation. Additionally, col-

laborative work is based on a shared situational awareness between team members.

The combination of a skilled workforce and shared situational awareness enables colleagues to be proactive in problem solving. This also keeps coordination costs low in relation to inside functions, in the team, between teams, and vis-a-vis external functions, which secures effective problem solving. For instance, after a planning/preparation session at Kristin, offshore personnel typically go to the workshops and out into the processing plant (Næsje et al., 2009: 1411; Skarholt et al., 2009). Maintenance work orders, partly set up by onshore Kristin personnel, are retrieved from the IT plant maintenance system (SAP), and for each role or discipline there are a set of programmed/scheduled activities and a set of corrective activities. These are set up according to company business processes for maintenance work. These are all part of the planned activities for the week and are coordinated and managed by the integrated management team. There is one planning meeting for the operations and maintenance crew, with one person attending who is responsible from each discipline. By responding to the requirements of other tasks, the operators can actually choose which work orders to complete or start.

One technician described his planned task when the scheduled refurbishment of a large valve was moved to after lunch time. When this decision was taken during the planning/preparation session in the morning, he went back to SAP to find something less complex to fill his day until lunch. The technician argued that he always had a set of work orders at hand, in order to be "doing something useful". Another technician contrasted this new situation with previous experience from an older installation.

At my old installation I was given a task on paper by my supervisor. I had not been involved in the planning of this task and had to spend considerable time to understand what to do, who to collaborate with, and what resources I needed. The supervisor should in theory provide the resources and coordinate the work for me. However, this seldom worked as planned, so we had to sit down and wait until everything was ready. Many times we gave up and were given new tasks, but more waiting for resources to do the job followed.

This quote is a contrast to how self-synchronization practice makes the organization more robust and can withstand changes and unscheduled situations. The essence is that operators have a certain amount of sway over which work orders to complete. They are given the premises or intent of what goes on in the larger operations and maintenance crew and what is prioritized by management. Næsje et al. (2009: 1411) show how these decisions are made at the lowest possible level, where personnel have full responsibility for the task, including its planning, execution, and reporting. They must do considerable boundary-spanning work to develop this shared understanding and decide what is best to prioritize, and it is also a way to deal with the synchronisation challenge. It means that onshore experts must be consulted, spare parts must be found or ordered before execution, and work is reported in one integrated loop. Trustful relationships are also here of utmost importance. The Kristin operation governance model relies on the fact that the operations and maintenance tasks performed by offshore operators are dependent on remote support from onshore discipline experts (engineers). Within all disciplines on board (electro, mechanics, automation etc.) there is an onshore engineer responsible for planning and supporting the work of the different discipline teams on the platform. The crew on the platform is very much dependent on the skills and knowledge of these discipline engineers, and on their availability in the daily decision-making and task-solving processes (Skarholt & Torvatn, 2010).

As in the first case the onshore engineers and the offshore workers within each discipline

know each other quite well and have also met face-to-face. The engineers go offshore two to three times a year, on average. Both the engineers and the offshore workers stress the importance of meeting face-to-face, because technical problems are solved more smoothly and rapidly when the engineers know the production site and its technical equipment thoroughly.

I cooperate closely with the offshore workers. ...I am in daily dialogue with them. Together we discuss technical challenges and problems. (Onshore engineer)

They [the offshore workers] can trust me. I keep my promises in my efforts to support them. And I include them in my work by involving them in planning and executing of the offshore operation and maintenance of tasks. (Onshore engineer)

Trust between the onshore engineers and offshore workers here rely on their understanding or opinion of each other's skills and competence. The engineers appreciate the high level of experience and competence among the offshore workers and vice versa:

They (the operators) are highly skilled, work independently, and know the platform very well" (onshore engineer)

We are very satisfied regarding the support and follow-up performed by the onshore engineer. (offshore worker/operator)

These two quotes indicate that that trust is embedded through the integrated operation and maintenance work practices. The offshore workers trust the abilities, experience, and knowledge of the onshore discipline engineers, to support their work offshore. The engineers have proven their expertise with the quality of work and behaviour necessary to accomplish successful production at the platform. Trust building between the onshore engineers and the offshore workers has encouraged offshore personnel within all disciplines to be proactive in problem solving and consequently it has become easier to detect and prevent errors.

Thus, we find that the combination of self-synchronization and boundary spanning is essential to get the work done efficiently. This fit dependency is increasingly seen as a synchronisation challenge, since IO to a large extent has contributed to this increased integration between the onshore and offshore personnel. Some of the personnel explain how IT based collaboration enables collaboration across boundaries and supports the self-synchronization and boundary-spanning process. One example deals with the virtually co-located Kristin onshore–offshore management teams:

When I sit in the video conference most of my working day I actually see whether the person is available. I can approach the person directly or call him. This creates a great awareness of what is going on.

...a main advantage is to be able to read facial expressions and body language. This is highly important. We focus heavily on the quality of sound and picture. It is the most important, much more so than other technologies.

In the video conference there are four things we keep on the agenda all the time. We address how we can improve the health, environment, and safety level of the plant. We keep up the production, know the technical condition of the plant, and control the operational costs.

We see that because of a shared and mutual understanding of goals and visions, the Kristin resources are better coordinated through collaboration. Knowing how to solve problems when they occur and trust in each other's knowing also require necessary self-synchronization among colleagues. Transparency in the form that action (or lack thereof) is visible through the IT artefacts used through organizational transparency is im-

portant in an organization like Kristin. Knowing through self-synchronization includes exercising judgement, the capacity to make interpretations, and the ability to use information, technology, and knowledge as knowing in practical work.

CONCLUSION

Through both cases we argue that boundary spanning and self-synchronization practices improve collaboration across boundaries in distributed/ virtual teams in integrated operations. Such practices are important to understand how people, process, governance and technology capabilities are developed and sustained. Due to the character of integrated operations fit dependency is increasingly seen as a synchronization challenge. We also find that knowledge sharing relies on management, trust, shared situational awareness, transparency, and ICT as important enabling capabilities that influence the collaboration across boundaries between the onshore production engineers and the offshore control room operators. Boundary spanning helps production engineers adapt to dynamic situations in collaborative work when crossing boundaries. Production optimization is dependent upon the integration of formal organizational factors and technology. Thus, boundary-spanning practice relies heavily upon knowledge sharing, shared situational awareness, and trust. Trust is related to the competence of employees offshore and onshore, and also to trust in the technology and its uses. Another enabling capability is shared access to ICT and information. One important issue here is the sensitivity of the organization concerning the treatment of knowledge. In Case 1, swift trust created the starting point for a more personal trust between people offshore and onshore. This is a subtle communication process where creating trustworthiness is a key concern. Collaboration technologies and visualization artifacts can support boundary-spanning processes and ease the development of transparency in such teams by providing an improved feeling of "being in the same room", but it can also alienate. Recognizing that the offshore control room operator had not done the well test was easy. Still, it was this subtle handling of the group of production engineers that saved the situation. In this sense trust represents a positive assumption about the motives and intentions of another party, it allows people to economize on information processing and safeguarding behaviors (McEvily, et.al 2003; 92).

In both cases we find how critical it is to know a colleague's competence to be able to share knowledge across boundaries. Team members adjust their language and practice depending on the social context because they know what language is appropriate. When members get together in collaborative environments a shared language is used, creating a shared situational awareness that is facilitated by technological-visualization tools. However, collaborative work across boundaries is challenging. This is not just related to the new and advanced information technology itself. It also involves organizational aspects in addition to shared goals and visions, trust, and the willingness to share knowledge. In the end, self-synchronization and boundary-spanning practices and the enabling capabilities are intermingled. Practices and capabilities are integrated as a question of knowing through collaborative work.

Knowing (being able to frame the situation and find ways of collaborative working), includes exercising judgment, the capacity to make interpretations, the critical assessment of data/ information, and the ability to use information and knowledge as knowing in practical work. These are integrated key elements of boundary-spanning and self-synchronization practices. Accordingly, well testing or maintenance planning/execution is a continuous exercise of professional judgement in the effort to solve ongoing problems across boundaries. It also involves activities like validating, double-checking, comparing, and contrasting the different representations in order to make them useful (Hepsø, 2009).

Experiences from Case 2 on self-synchronization shows that shared situational awareness and understanding between virtual teams and especially between offshore and onshore teams are crucial. It outlines the importance of personnel taking responsibility for their day-to-day practices. In this example we see how the business process of operations and maintenance are matched with a governance model that creates the unique Kristin practices. Through shared situational awareness and shared language, the ability to create relationships, based on trust, increases. This means that it is problematic to treat the two cases as examples of traditional fit dependencies. They are instantiations of the synchronization problem; constraints on the arrangement of multiple things and effects. Each activity involved in producing part of the overall arrangement must take into account the output of the other activities that contribute to this arrangement.

Finally we also see that the practices to improve collaboration across boundaries and the enabling capabilities are inter-connected through daily work in the sense that they mutually influence each other. Self-synchronization practice can improve the conditions for knowledge sharing and a good standard in the enabling capabilities might result in improved self-synchronization practice.

REFERENCES

Abrams, L. C., Cross, R., Lesser, E., & Levin, D. Z. (2003). Nurturing interpersonal trust in knowledge-sharing networks. *The Academy of Management Executive*, *17*(4), 64–77. doi:10.5465/AME.2003.11851845

Alberts, D. S., & Hayes, R. E. (2003). *Power to the edge command control in the information age*. Washington, DC: CCRP Publication Service. Retrieved September 20, 2009, from http://www.dodccrp.org/files/Alberts_Power.pdf

Ardichvili, A., Page, V., & Wentling, T. (2003). Motivation and barriers to participation in virtual knowledge-sharing communities of practice. *Journal of Knowledge Management*, *7*(1), 64–77. doi:10.1108/13673270310463626

Blackler, F. (2004). Knowledge, knowledge work and organizations: An overview and interpretation. In Starkey, K., Tempest, S., & McKinlay, A. (Eds.), *How organizations learn. Managing the search for knowledge* (pp. 339–362). London, UK: Thompson Learning. doi:10.1177/017084069501600605

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning, and innovating. *Organization Science: A Journal of the Institute of Management Sciences, 2*(1), 40.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455. doi:10.1287/orsc.13.4.442.2953

Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science*, *15*(5), 555–568. doi:10.1287/orsc.1040.0094

Cross, R. L., & Parker, A. (2004). *The hidden power of social networks: Understanding how work gets done in organizations*. Boston, MA: Harvard Business School Press.

Gherardi, S. (2006). *Organizational knowledge: The texture of workplace learning*. Malden, MA: Blackwell.

Gherardi, S., & Nicolini, D. (2000). The organizational learning of safety in community of practices. *Journal of Management Inquiry*, *9*(1), 7–18. doi:10.1177/105649260091002

Henderson, J. C. (2011). Coordinating distributed real-time business processes: Understanding the synchronization problem. Presented at International Conference on Information Systems (ICIS) 2011, December 4-7 Shanghai.

Hepsø, V. (2008). Boundary-spanning practices and paradoxes related to trust among people and machines in a high-tech oil and gas environment. In Jemielniak, D., & Kociatkiewicz, J. (Eds.), *Management practices in high-tech environments* (pp. 1–17). Hershey, PA: Idea Group. doi:10.4018/978-1-59904-564-1.ch001

Hepsø, V. (2009). The role of 'common' information spaces in knowledge intensive work. Representation and negotiation of meaning among oil and gas subsurface specialists in computer supported collaboration rooms. In Jemielniak, D., Kozminski, L., & Kociatkiewicz, J. (Eds.), *Handbook of research on knowledge-intensive organizations* (pp. 279–294). Hershey, PA: Idea Group. doi:10.4018/978-1-60566-176-6.ch017

Hertel, G., Konradt, U., & Orlikowski, B. (2004). Managing distance by interdependence: Goal setting, task interdependence, and team-based rewards in virtual teams. *European Journal of Work and Organizational Psychology*, *13*(1), 1–28. doi:10.1080/13594320344000228

Jarvenpaa, S. L., Knoll, K., & Leidner, D. E. (1998). Anybody out there? Antecedents of trust in global virtual teams. *Journal of Management Information Systems*, *14*(4), 29–64.

Kasper-Fuehrer, E. C., & Ashkanasy, N. M. (2001). Communicating trustworthiness and building trust in interorganizational virtual organizations. *Journal of Management*, *27*, 235–254.

Kotlarsky, J., & Oshri, I. (2005). Social ties, knowledge sharing and successful collaboration in globally distributed system development projects. *European Journal of Information Systems*, *14*, 37–48. doi:10.1057/palgrave.ejis.3000520

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York, NY: Cambridge University Press.

Levina, N., & Vaast, E. (2005). The emergence of boundary-spanning competence in practice: Implications for implementation and use of information systems. *Management Information Systems Quarterly*, *29*(2), 335–363.

Lines, R., Stensaker, I. G., & Langley, A. (2006). *New perspectives on organizational change and learning*. Oslo, Norway: Fagbokforlaget.

Malhotra, A., Majchrzak, A., & Benson, R. (2007). Leading virtual teams. *The Academy of Management Perspectives*, *21*(1), 60–70. doi:10.5465/AMP.2007.24286164

Malone, T. W., & Crowston, K. (1994). The interdisciplinary study of coordination. *ACM Computing Surveys*, *26*(1), 87–119. doi:10.1145/174666.174668

McEvily, B. (2003). Trust as an organizing principle. *Organization Science*, *14*(1), 91–103. doi:10.1287/orsc.14.1.91.12814

Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In Kramer, R. M., & Tyler, T. R. (Eds.), *Trust in organizations: Frontiers of theory and research* (pp. 166–195). Thousand Oaks, CA: Sage. doi:10.4135/9781452243610.n9

Næsje, P., Skarholt, K., Hepsø, V., & Bye, A. S. (2009). Empowering operations and maintenance: Safe operations with the 'one directed team' organizational model at the Kristin asset safety. In Martorell, A. (Eds.), *Reliability and risk analysis: Theory, methods, and applications* (pp. 1407–1414). London, UK: Taylor & Francis Group.

Nicolini, D., Yanow, D., & Gherardi, S. (2003). *Knowing in organizations: A practice-based approach*. Armonk, NY: M.E.Sharpe

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford, UK: Oxford University Press.

OLF Norwegian Oil Industry Association. (2005). Integrated work processes: Future work processes on the Norwegian Continental Shelf. Retrieved September 21, 2009, from http://www.olf.no/getfile.php/zKonvertert/www.olf.no/Rapporter/Dokumenter/051101%20Integrerte%20arbeidsprosesser,%20rapport.pdf

Orlikowski, W. J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. *Organization Science*, *13*(3), 249–273. doi:10.1287/orsc.13.3.249.2776

Pawlowski, S. D., & Robey, D. (2004). Bridging user organizations: Knowledge brokering and the work of information technology professionals. *Management Information Systems Quarterly*, *28*(4), 645–672.

Perrow, C. (1999). *Normal accidents: Living with high-risk technologies*. Princeton, NJ: Princeton University Press.

Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: A review of current literature and directions for future research. *ASM SIGMIS Database*, *35*(1), 6–36. doi:10.1145/968464.968467

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. S. (2009). Integrated operations and leadership – How virtual cooperation influences leadership practice. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications* (pp. 821–828). London, UK: Taylor & Francis Group.

Skarholt, K., & Torvatn, H. (2010). Trust and safety culture: The importance of trust relations in integrated operations (IO) in the Norwegian oil industry. In Bris, R., Guedes Soares, C., & Martorell, S. (Eds.), *Reliability, risk and safety: Theory and applications* (*Vol. 2*, pp. 1285–1291). London, UK: Taylor & Francis Group.

Tsoukas, H. (2005). *Complex knowledge: Studies in organizational epistemology*. New York, NY: Oxford University Press.

von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation. How to unlock the mystery of tacit knowledge and release the power of innovation*. New York, NY: Oxford University Press.

Weick, K. E., & Sutcliffe, K. M. (2001). *Managing the unexpected – Assuring high performance in an age of complexity*. San Francisco, CA: Jossey-Bass.

KEY TERMS AND DEFINITIONS

ICT: Information and communication technology.

IO: Integrated Operations.

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Chapter 6
Teams:
The Intersection of People and Organisational Structures in Integrated Operations

Dominic Taylor
Wipro Oil and Gas Consulting, UK

ABSTRACT

The success and sustainability of the Integrated Operations (IO) initiative within the Oil and Gas industry is discussed in relation to the ways people work together and the organisational structures which support that work. Whilst collaboration has become a defining concept in the industry for optimal working, this chapter argues that other characteristics found in the concept of teamwork are of equal importance in achieving the aims of the IO project. Teams and high-performing teams can provide a framework for understanding how groups of people within the workplace can respond to the dynamic environments of the oil and gas industry and fulfill the objectives of IO. The chapter presents some tactics for creating high-performing teams within this domain and presents two case studies to show the importance of teamwork in realizing the goals of Integrated Operations.

INTRODUCTION

The Integrated Operations (IO) initiative within the Oil and Gas industry is truly 'transformative' as it aims to change the ways we approach our work and organise ourselves. Much of this transformative capability, especially within the context of the workforce, is articulated with reference to 'collaboration'. Its importance has come to define the ways in which oilfield workers should interact with each other and is seen as a key quality in answering the industry's current set of challenges. That collaboration has become such a buzzword

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is perhaps not surprising given the distributed and specialised nature of the industry, however its dominance might be obscuring other equally important characteristics and qualities.

This chapter will look at the people-related and organisational elements of the IO initiative within the industry. It is commonly agreed that the people and behavioural aspects of IO programmes are key determinants of success and this is particularly true in sustaining success over the long term. The chapter will focus on the organisational structures in which the varied roles within the oilfield undertake their work and interact with each other and argues that the concept of teams and high-performance teamwork are of critical importance within the Integrated Operations project. IO practitioners and project managers need to consider how the formation and continued performance of the team can contribute to the success of their projects.

BACKGROUND

Within Integrated Operations, the concept of collaboration has become a key enabler for the programme's transformative aims. The concept is well documented throughout the industry: the various roles within a business process are encouraged to work together, to pool their knowledge and insights across their disciplines, and so to make decisions in the 'round' with all the information needed to make better decisions, faster and more efficiently. The concept could also be seen to extend to collaboration with data: as real-time data has become more available, so the typical asset can be run with greater responsiveness to real- or near-time operating conditions.

There are perhaps three reasons why collaboration has come to the fore within the industry. First, is the typical architecture of a typical Oil and Gas company with a highly distributed workforce, coupled with a strong need to communicate across this workforce who are functionally organised. Second, are the opportunities for enhanced communication provided by the recent advances in communication technology, particularly video-conferencing. Third, the increasing availability of real-time data from all parts of the asset has allowed for, and necessitated, a more real-time response, so requiring a quicker and arguably more integrated approach.

Collaboration has not only these distinct drivers but also is seen as one of the key mechanisms by which to address the critical issues facing the oil industry. There is strong agreement on these challenges: first, a marked gap in the key skills in the industry brought about by an ageing workforce; second, challenging production and cost efficiency targets as demand and competition increases; third, the distance of the new fields from the centres of skilled resources and fourth, the increased complexity, whether physically or geo-politically, of the new fields and locations (Edwards, Mydland & Henriquez, 2010). Collaboration has become a critical element within the industry for addressing these issues and is one of the key behaviours looked for when considering the people element in IO projects.

PEOPLE AND ORGANISATIONAL FACTORS IN IO PROGRAMMES

The typical IO initiative is usually described within a tri-partite or four-part framework of Technology (including both engineering hardware and information technology), Process and People. The fourth element, arguably a later addition, relates to the organisational context of structures, governance and incentives in which the IO program functions (Edwards, Mydland & Henriquez, 2010).

It is the people and organisational elements of this framework which are the main topics of this chapter. The 'people' element of this IO framework is made up all of the roles undertaken within the business processes but also encompasses the attitudes and behaviours of the people in scope. It

is well-recognized that the people element of an IO project is a critical component: get this wrong, and the project or programme will not be entirely successful. However, any attempt to prioritize one element of the IO framework over another is not productive. Rather, as has been argued earlier in this anthology, we should view the people element as one part of the IO capability platform – for value to be recognised, all dimensions need to come together (Henderson et al, 2012).

The organisational aspect spans both the micro and macro levels ranging from the local team to the company-wide governance structures and incentives which dictate the overall direction of the IO programme (Edwards, Mydland & Henriquez, 2010). It is the micro-level that interests us here and particularly how it intersects with the 'people' element of the IO equation. In designing successful IO programmes and projects, the question could be asked as to which organisational structures best support the people undertaking these new Integrated Operations activities and behaviours.

LIMITS OF THE COLLABORATION MODEL

The behaviours and working practices introduced by the focus on collaborative working have certainly had some success (Hauser & Gilman, 2008). The introduction of initiatives around collaborative working environments and decision environments have been credited with achieving the core objectives of Integrated Operations and achieving significant bottom-line benefits such as increased production and decreased operating costs (Judson & Ella, 2007). However, it could be argued that the prevalence of the term, and its application across many of the aspects of IO, is stretching the limits of its usefulness. To 'collaborate' has become short-hand for any sort of interaction between people, functions and departments and this short-hand has obscured some of the complex dynamics between people and within organisations in IO programmes.

It is instructive to think through the aims of the typical asset IO project within this frame of people and organisational structures: first, to create true multi-disciplinary working so decisions take into account all aspects of the operation. Second, to ensure a real-time or near real-time picture of the asset, driven by data, can inform decision making and lead to production improvement and cost reduction. Third, to ensure that remote locations are working together productively in a synchronized manner and with one aim. Fourth, the asset needs to consider how to bring all these elements together within the context of challenging production targets and recovery rates.

Each of these aims above has a people and organisational element to them. To create true multi-disciplinary teams we need to have understanding of the roles within the organisation and how each role contributes to the overall picture. To act effectively as a multi-disciplinary team we also need to have cohesion, defined as being organised with self-awareness of how the group functions and the roles and inputs needed to operate effectively. Crucially, this is underpinned by trust which has both a technical element (does this person show they can bring the requisite skills to the role?) and a social element (does a colleague share the same goals and can they be relied upon to act in the interests of the organisation and their colleagues?).

To realise the benefits brought about by availability of real-time data and the ability to share that data with remote locations to work productively together, we need to consider how we create a shared understanding of the operating environment. This shared understanding, or shared 'situational awareness', allows us to collectively understand what is going on in the asset and provides a basis for understanding how to act in a synchronized manner (Edwards, Mydland & Henriquez, 2010). In complex, dynamic environ-

ments situational awareness is critical for success and is driven in part by robust mental models of the environment. This is particularly important where people are at different locations as their physical separation, and very different working environments, makes it more difficult to share data, update their mental models, and create a shared understanding of the asset. The absence of a shared situational awareness can mean activities are not synchronized, leading to inefficiencies, and opportunities not capitalized upon.

All IO projects are set within a context of challenging production targets and cost reduction initiatives. These targets and objectives provide another people related and organisational challenge in that people need to be 'bought into' these objectives at a fundamental level; without commitment to stretching objectives they are unlikely to be achieved. A key issue for the asset is how to translate the larger, asset-wide objectives into more specific targets appropriate for smaller groups.

The typical IO project is thus faced with a number of people and organisational issues fundamental to the success of its vision. It might be argued that many or all of these are the necessary pre-conditions for collaboration, however, qualities such as group cohesion, trust and commitment, are of equal importance and are equal determinants of success for the IO project. This paper will explore the idea that these personal and organisational characteristics are best realised in the concept of the team.

THE CONCEPT OF THE TEAM

The concept of the team lies at the intersection of the organisation with a person's role and motivation. It is one of the most basic building blocks of the organisation. Why is the concept of the team useful? It is in this, usually small-scale, organisational 'unit' in which people can make sense of their role and their working purpose. The team allows the coming together of multiple skills, experiences and judgements in a much more effective way than within a group of individuals confined by their job descriptions. Teams are flexible and they encourage performance by having more tangible and stretching goals than a loosely arranged group (Katzenbach & Smith, 1993). It is this ability to connect individual performance to organisational goals and the strength in bringing together multi-disciplinary teams focussed on stretching targets that make teams and teamwork such an appropriate model for IO programmes. And it could also be argued that the creation of multi-disciplinary teams is the necessary pre-condition for collaboration.

Teams and teamwork are relatively old-fashioned concepts in business and considerable analysis has been done on their dynamics, construction and factors guaranteeing success. It is also recognized that teams and teamwork are important to this industry and some effort is given to the way they operate. However, the discussion of the role and importance of teams within IO is muted. Certainly there are difficulties in defining teams within the industry for the many of the reasons why collaboration is considered so important: people who might operate as a team are geographically distributed; they are often organised by discipline and they often have participants from different working cultures. The concept of the team within the Upstream industry is also complicated by the matrix structure of the typical organisation (Guldemond, ten Have & Knoppe, 2010). A central team asset could include offshore team leaders with onshore asset management and well, reservoir and maintenance representatives. However, each of these people is likely to exist in their own teams; certainly offshore there are likely to be a core leadership team and functional teams under them. Likewise, an onshore Reservoir Engineer could be as much within her Subsurface team as in the asset team.

Despite this there are certainly opportunities within the industry, and the IO programme, for creating distinct teams. In the typical Production Operations scenario, with an asset leadership team including team leaders from various disciplines, there is the ability to build a properly functioning team as they have a distinct identity and clear performance goals. Likewise one could look across other parts of the organisation to find examples where teams are readily identifiable through a collective aim. A drilling team moving through the process from well design through to drilling operations and hand-over or a Well Engineering team specialising in a particular form of well workover could have enough definition to function as a team. The question arises as to what constitutes a proper team and how does it become a high-performing one?

Teams and High-Performance Teams

There are a number of definitions available for what constitutes a team, but some common themes can be recognised. Team size is an important consideration, with some suggesting that teams reach their natural limit at about 25 members (Katzenbach & Smith, 1993). Anything larger than this leads to difficulty in creating a distinct identity and ensuring team members are aligned in their approaches and objectives.

The right mixture of skills is an obvious component, and this is particularly true in specialised environments such Upstream Oil and Gas. Skills include the technical skills needed for the job, but also encompasses problem-solving and social skills; it is recommended that the first of these should neither be over-emphasized, as is often done in specialist environments, nor under-emphasized in favour of the right social mix (Katzenbach & Smith, 1993).

Possibly the most influential factor in creating strong teams is the formation of a common and meaningful purpose. This purpose can be influenced by external management but also be distinct from it in terms of its specific focus or flavour. The team's stated purpose provides a context for the individual efforts of each team member and its creation can also be an activity that itself helps to form and unite the team. Success, it can be argued, is when the personal motivation of individual workers is directed towards a common, and organisationally desirable, goal.

The team purpose needs to be measurable and this leads to another important characteristic of teams: performance goals. Performance goals are the ways in which 'purpose' is realised and the deliverables of the team distinguish the team's output from the larger goals of the organisation, albeit aligned.

There are a number of key internal team behaviours which could be grouped around a team's 'approach'. These include the quality and frequency of team communications, the sense of a shared responsibility, a common set of assumptions about the way in which the team will undertake its actions and fulfill its commitments. This would include, for instance, a sense of equality on the amount of effort team-members are contributing and agreed working practices governing key processes. Finally, there is a commitment to the team members in ensuring the people are adequately supported both from a skills perspective and in terms of functioning as a member within the team.

The above characteristics are what Katzenbach and Smith call the 'team basics' and are a prerequisite for any definition of a properly functioning team (Katzenbach & Smith, 1993). They argue that the move to becoming a 'high-performing' team comes through a deep commitment to the team's purpose and to each other that goes beyond teamwork protocols. One could argue it is the creation of trust and in the workplace this must include a sense of technical or professional trust combined with a 'social' trust. This social trust is based on an appreciation of another's strengths, weaknesses, and motivation and a feeling that another team member can be relied upon for support in all circumstances.

Application to Upstream Teams

As noted before there are some distinct challenges in forming strong or high-performing teams within the Upstream industry. Indeed, many of the reasons why it is so difficult to form teams are the very factors which make collaboration so necessary. These reasons however have a particular effect on any notion of team.

First, the highly distributed nature of the workforce means that for some teams there is a difficulty in creating identity or unity. It can be easier to create teams when co-located as a team environment and ease of communication promote robust team behaviours. Where team members are not co-located, there is a potential for communication to decrease, the sense of a common purpose does not get reinforced, and the team's behavioural norms do not get synchronised very often. Another factor in the virtual team, is that the lack of visibility can also mean, within a team context, a loss of focus on the team member's productivity. This can have a negative effect on motivation factors and can result in a loss of productivity and a sense that different team members are contributing unequally. Second, the multi-disciplinary nature of the typical IO team has its own challenges. The strong functional skills which are needed to answer the particular challenges of the asset can make consensus on team 'approach' difficult to agree.

These challenges make it even more critical that the team basics outlined earlier are brought into play when putting together IO teams. Where, for instance, team identity is not supported by co-location then factors such as communication, creation of a strong team purpose and challenging and tangible performance goals become even more important. Also, as we will see, there are specific tactics the IO practitioner can use to overcome these challenges.

TACTICS FOR BUILDING HIGH PERFORMING TEAMS

There are some distinct challenges in forming high-performing teams within the Upstream Oil and Gas industry and some appropriate tactics to help answer these challenges:

- Creation of a distinct and strong identity: The importance of creating of a strong team identity cannot be over-emphasized. The team needs to be marked out as a team, and this involves at a basic level a name, a clear sense of the team members, a compelling purpose (outlined below) and a common operating model.

The power of deciding on a unique team name should not be under-estimated, even though it can appear a superficial factor. Experience of working with teams who are going to move into Collaborative Environments has shown that a unique name has had a unifying effect on a group of people who are facing the possibility of disruptive change. Crucially the name needs to be chosen by team and not imposed.

- IO practitioners should also consider how the team fits together from not only the technical skills needed (subsurface, wells, maintenance etc) but also what roles they perform within the team. There are various useful models for understanding team-role types, one of the most well-known and useful being Belbin's team roles (Belbin, 2011 and following). A well–balanced team, according to Belbin, should have representatives across eight different roles types: The 'Plant', the creative force within the team (p.43), the 'resource investigator' who 'are particularly adept at exploring resources outside the group' (p.45), a 'monitor evaluator' who provides a logical, impartial view

and who can unemotionally weigh up the team's options (p.65), a 'co-ordinator' who clarifies the team's direction, ensures that team members play 'their roles effectively' and delegates work appropriately (p.53). 'Implementers' are needed to plan a practical, workable strategy and carry it out as efficiently as possible (p.35). A 'completer finisher' who sees the task through in all its detail and proves quality control (p.70), a 'shaper' who drives the project forward and ensures that the team doesn't lose focus or momentum (pp.56-58). A 'teamworker' is a social role which understands the team dynamic, can help the team work together and can use their emotional skills to avert conflict (p.70).

Each of the above roles brings a slightly different focus to the team and the combination is seen by Belbin as being highly effective in achieving results. Whatever the model or role definitions that are used, it is worth considering the non-technical roles that each team member plays: there will be some more assertive than others, some seemingly more critical, and an imbalance if left unexamined could lead to some dysfunctional decisions or actions. What is interesting is that the role of the leader is not explicitly identified by Belbin. There are some roles that would lend themselves more to the leadership role, such as the action oriented roles typified by the Implementers and Shaper or the more people-centered Co-ordinator role. This issue of team leadership within IO organisations will be addressed later.

- Create trust 'face-to-face': trust, and so the foundation for a team, is best formed through face-to-face meetings. This can be enormously challenging for IO practitioners and Upstream leadership as offshore work and shift patterns prohibit a full team meeting. However, the process of getting to know a 'face' and understanding another potential team members point of view and motivation (see discussion of Belbin above) can have enormous benefits in creating team identity through the simple fact of understanding who is 'in' the team.

Videoconferencing technologies can play a part in this process, although it can be argued that this technology usually supports pre-existing behaviours and social dynamics rather than create new ones. However, there is anecdotal evidence from the use of videoconferencing technologies in the offshore-onshore situation, where the simple fact of seeing a colleague's face via the videoconference cemented a working relationship.

- Form a compelling goal: as stated previously, most IO teams' objectives will sit within an organisation's larger set of goals and objectives, usually a 'balanced scorecard' approach across a number of different factors including financial, safety and the environment. However, this does not preclude forming and focussing a team around a certain challenge. This might be, for instance, in a Well Work-Over team installing a number of velocity strings or a centralised Production support team becoming the first port of call for all 'difficult' Production and Well challenges across the organisation. To be compelling the goal has to combine a person's individual motivation – to be the best, the most trusted, recognized – with a tangible business goal.
- Create a shared understanding of team protocols and behavioural norms: the formal ways in which the team interacts through meetings and communications can be collectively agreed and documented. This can then become part of a team charter to set the expectations for how the team will work together. At its simplest it sets out the structure of the working week, however it also defined what is important to the team

and a collective statement of individual team-member's responsibilities.

- Use the collaborative and networking technologies to support team behaviour: in the virtual team one of the main dangers, and fears of participants, is the sense of not participating through being physically absent. Functionality found within Instant Messaging and portal technologies, which give a user an indication of who is online and available to talk, can be a simple but effective way of creating a sense of virtual team presence. The interaction with team-members can be made that much easier by initiating a conversation by an instant message and the continuing on another media type, such as videoconference.
- Be prepared to help a team through its life-cycle: the key theme in this anthology is sustainability and this is applicable to the team as well. Teams can be seen to move through distinct phases, from a 'working group' to a 'pseudo-team', through to a real team and possibly up to a high-performing one (Katzenbach & Smith, 1993). The move from a 'working group', which is a group of people with no need for further integration, to a 'pseudo-team' is a move down the performance curve where the whole (the team) is less than a the sum of its parts. To move up the curve to a properly functioning team means the instigation of basic team behaviours, as outlined previously, and the move upwards to high performance a heightened commitment to each team member. Navigating the curve, and overcoming any blockages, takes some insight and commitment from both the leadership and any coaching or support that might be available.

LEADERSHIP AND SELF-MANAGING TEAMS

Something missing from the discussion so far is any reference to leadership. In most discussions of teams, the presence and quality of the leadership is considered an important characteristic. Undoubtedly leadership has a critical role to play in helping the team operate effectively: they can help set direction, act as the main interface with senior management and other key stakeholder groups, provide a model for the behaviour of the high-performing team, and use their social skills to encourage team cohesion and provide mentorship.

However, given the virtual nature of many teams and the organisational context in which they exist, leadership is often absent or indistinct. The prevalence of the matrix structure, with potential leaders for a person duplicated both within the discipline (the horizontal reporting line) and within the business unit (the vertical reporting line), often confuses the situation (Guldemond, ten Have & Knoppe, 2010). Added to this is a changing dynamic in the workplace. The mobility of specialist resources (especially in this resource-constrained industry) combined with a generational shift in the relationship between the individual and institutions have changed the contract between the person and the employer-organisation. The organisation no longer has the sort of authority over the employee as it used to. This means the role of the leader, and all it entails, has become a difficult role to perform.

Leadership therefore has to exit in a more circumscribed role and the team may need to look to itself to establish the direction and drive which might normally be provided by a leader. Self-managing teams are becoming more feasible in flatter, less hierarchical organisations where people have high levels of autonomy. This could be particularly true in the Upstream context where people have responsible and technically demanding roles and can often be highly self-motivated. There are advantages if one person is identified

as the team leader, not least to act as the external face to the organisation, however it can be possible for high-performing teams to spread the required leadership behaviours amongst its members.

THE CHALLENGE OF VIRTUAL ORGANISATIONS

As noted in this anthology and elsewhere, the oil industry is becoming more virtual, more networked, as an 'ecosystem' of partners, suppliers and vendors, contribute towards common business objectives (Hepso, 2006). Thus collaboration and co-operation across organisational boundaries becomes a key factor. The concept of team can become stretched at this point or be inappropriate. Often a 'core' asset team will have to work with individuals or teams from other organisations and so collaboration is necessary but without the background of the team structure. Although they will jointly have to work out communication and collaboration protocols to work effectively together, these external parties do not share, for instance, in the team's identity or objectives.

The concept of the team can therefore become porous, as often it will involve people and other groups from outside its own border. People within these increasingly networked organisations will have to navigate a number of different organisational models: they will possibly identify primarily with a core team, but also participate in other groups who may come together for very specific purposes at varying frequencies. Different behaviours and strategies will then be needed to work effectively with these external parties. When parties have slightly different objectives or limited resources, then the challenge can become as to how these parties can manage conflict and negotiate good outcomes (Weiss and Hughes, 2011). As Weiss and Hughes (2011) argue, managing conflict becomes the key part of the collaborative contract as parties work out 'wise trade-offs' to come to 'creative solutions' (p.70). Collaboration therefore becomes a quite different activity when crossing these organisational boundaries and quite different strategies are needed.

CASE STUDIES

There are examples within the industry and its experience of implementing Integrated Operations projects of the importance of the team concept. Presented below are two examples of where the formation of team had a profound impact on the success of IO projects[1]. In both cases, the ostensible aims of the projects were about collaboration, but what follows shows how an important the concept of teamwork was to achieving the IO benefits.

The first project involved the Production group of an onshore oil field in the Middle East. The challenge was to create a more integrated organisation that could optimize production in a more proactive and systemic manner. There was a consensus that the asset could be more productive and should operate within an operating philosophy which looked at the long-term health of the well stock rather than short-term gains.

The project had all the typical streams within an IO project. First, there were efforts within the organisation to improve the access to real-time data and do this in a structured way so that engineers had the relevant information in the right format and graphical interface. Second, continuing the technology theme, there was the introduction of expert systems to models to aid decision making. Third, the organisation looked at the processes and working environments and thus the people and roles involved.

In the course of the project, which was focussed on process change and collaboration, a number of changes took place at the organisational level, and it became clear that team structure and formation were going to be key to achieving project success. A number of observations can be made:

- Team identity became came sharply into focus when a name was chosen. This was done collaboratively in a face-to-face workshop and the process itself created a team bond. The simple identification of the different roles and the parts they would play in achieving the team objectives made clear the value of each team member. For instance the people responsible for the Production Optimization 'expert system' were seen as key contributors rather than just an IT project and a sideline.
- A definite sense of purpose was created around a desire to achieve the stretching production targets the asset had been set by management. In this case, there was a purpose imposed by management but the team made that purpose become their own. In part, this could have been due to the obvious focus the organisation was giving to the asset in terms of management time, and the new tools and environments (see below).
- Field staff, brought into the face-to-face design meetings, became some of the most enthusiastic team members as they could see the value of operating as an integrated team and the ability to connect to new sources of advice and information. It showed that some of the more geographically remote team members can see the value of a tighter team and become its most enthusiastic proponents.
- The creation of a new working environment, including new collaborative meeting rooms, signalled a shift to the new structure and encouraged, through physical seating, a sense of a distinct entity and identity.

It should be re-iterated that this was not a project which set out to look at the creation of a team and all the attendant behaviours and characteristics. Its primary focus was on the tools and technologies that would allow for collaborative decision making across the asset, including the field personnel. It could be argued that for any collaboration to happen, a sense of team needed to be created here as the foundation for that behaviour. But, as argued before, what is equally important is that a properly functioning team also has qualities which help to achieve the benefits of the Integrated Operations project. Qualities such as a sense of commitment to a common purpose that was larger than the individual, an enthusiasm and flexibility driven by a positive attitude to change, and creativity in solving problems.

The second case study, from an offshore asset in the Gulf of Mexico, shows how a pseudo-team situation can exist for quite long periods. The onshore and offshore teams had theoretically been operating as a 'team' but in effect there were two distinct identities, with an onshore asset team tending to give orders and expecting offshore Operations to enact them. The implementation of an IO project to implement collaborative technologies across the organisation had a profound impact on the sense of team and so the eventual success of the project.

In this project, the use of video-conferencing technologies had an enormous impact on the cohesion of the team as team members were able to become visually present at meetings. It was remarked that members had become 'real people' and so trust and a stronger working relationship developed. The ability to look at the same data also had an effect on the team as both locations felt they were looking at one version of the truth, thus embedding a sense of a unified environment and a common understanding of the asset's performance. The creation of a properly functioning team, and consequently the awareness of the potential input from its various roles, culminated in extending the participants of the key management meetings to include offshore roles. So, for instance, meetings such as the weekly well reviews would include offshore personnel and involve a much more participative method of decision making. These changes had a great effect on the speed in

which changes to the asset were implemented, as the context and the importance of the changes were understood and activities were consequently prioritized.

SUSTAINING THE IO INITIATIVE

As the Integrated Operations programme grows in maturity, many more organisations are looking at how the initial transformations can be sustained and possibly re-invigorated. This focus on sustainability has led to organisations to re-examine some of the early implementations and on how to achieve the long-term success of projects beyond the immediate timeframe. So, for instance, we can see organisations looking at their three- to five-year-old collaborative environments to see if they are having the same impact as when first implemented or if the transformation can be extended to other processes and functions.

The mechanisms by which success is sustained over the long-term are usually related to people and work behaviours. For it is the continued change in behaviours which determine success as people interact with each other in different ways, use the new information resources they have available and come to decisions more effectively. In other words, the characteristics which underpin the IO project. One might extend this to include the organisational structures in which those people operate for it is the organisation which provides the framework for how people interact with each other and perform their roles.

If sustaining the aims of Integrated Operations becomes in part a people-centred and organisational concern, it demands that IO management consider the organisational structures in which people operate, and specifically the organisational unit of the team, as means of addressing sustainability. IO programme leadership will need to consider how to design their project initiatives within the framework of teams and team performance alongside the process re-design, collaboration, and change management project streams which have dominated to date. So to deliver sustainable programmes both the organisational and the personal level has to be addressed. To date, most of the people-centric work has focussed on either collaboration, as previously discussed, or within an individual model of 'motivation' offered by change management models. What IO programme and project leaders should also consider is the process the organisation goes through from initiation of the desired organisational changes to successful implementation and finally to sustenance of those changes.

The IO practitioner might therefore consider how to sustain high-performing team over time. This can include helping the team overcome team 'blockages' and move teams out of the pseudo-team state to a properly functioning one. It will involve an awareness that teams are likely to evolve, with members arriving and leaving, and therefore an understanding of how to keep a team's direction and cohesion intact.

CONCLUSION

The success, and sustainability, of the transformation promised by the IO initiative within our industry is dependent on many inter-related factors. Certainly collaboration has an important part to play to ensure that different parts of an organisation and ecosystem of partners, can share information and come to decisions. However, the challenging nature of IO projects – and the difficulty in sustaining the changes – means we have to consider the people and organisational aspects of the change. Teams are where people and organisations intersect. They can provide a highly productive way of 'grounding' the individual within an organisation and motivating them to achieve challenging goals.

The distributed nature of the industry is a particular challenge for building strong teams within Integrated Operations. However, it is worth

putting these challenges into a larger context as the rise in the virtual team is happening outside of the industry as communication technologies, cost considerations, and access to skills, are driving the formation of teams spread across the world. And the same technologies are changing the ways in which we communicate in our social world and, with every increasing transparency of information, changing our relationships to key institutions. It therefore remains to be seen what the effect of this cultural shift will have on our organisations within the industry. However, in bringing together highly motivated, multi-disciplinary groups of people, the concept of the team still appears to be the most compelling organisational answer to the challenges facing Integrated Operations.

REFERENCES

Belbin, M. (2010). *The management of teams: Why they succeed or fail* (3rd ed.). Oxford, UK: Butterworth-Heinemann.

Edwards, T., Mydland, O., & Henriquez, A. (2010, March). *SPE 128669*: *The Art of Intelligent Energy(iE) - Insights and lessons learned from the application of iE*. Paper presented at SPE Intelligent Energy Conference, Utrecht, Netherlands.

Guldemond, E., Ten Have, K., & Knoppe, R. (2010, March). *SPE 128274: Organisational structures in collaborative work environments: The return of the matrix?* Paper presented at SPE Intelligent Energy Conference, Utrecht, Netherlands.

Hauser, M., & Gilman, H. (2010, February). *SPE 112215: Evolution of decision environments: Lessons learned from global implementations and future direction of decision environments.* Paper presented at SPE Intelligent Energy Conference, Amsterdam, Netherlands.

Henderson, J., Hepso, V., & Mydland, O. (2012). What is a capability platform approach to integrated operations? In Rosendahl, T., & Hepso, V. (Eds.), *Integrated operations in the oil and gas industry: Sustainability and capability development*. Hershey, PA: IGI Global.

Hepso, V. (2006, February). *SPE 1000712: When are we going to address organisational robustness and collaboration as something else than a residual factor?* Paper presented at SPE Intelligent Energy Conference, Amsterdam, Netherlands.

Judson, J., & Ella, R. (2007, November). *Documenting DOFF value.* Paper presented CERA Executive Workshop, The Digital Oil Field of the Future (DOFF) Forum in Houston, USA.

Katzenbach, J. R., & Smith, D. K. (1993). *The wisdom of teams*. Boston, MA: Harvard Business School.

Taylor, D., & Fosse, K. (2006, February). *SPE 100704: Collaborative decision making in operations-centre environments*. Paper presented at the SPE Intelligent Energy Conference, Amsterdam, Netherlands.

Weiss, J., & Hughes, J. (2011). Want collaboration? Accept and actively manage conflict. *Harvard Business Review*, (3), 65–92.

ENDNOTE

[1] The two case studies are taken from the experience of projects undertaken by the author and a colleague, Helen Gilman.

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Chapter 7
Managing Team Leadership Challenges in Integrated Operations

Sjur Larsen
NTNU Social Research, Norway

ABSTRACT

This chapter gives an empirically based account of leadership of teamwork in Integrated Operations settings, or "IO teamwork" as it is termed here. First, a brief presentation of the characteristics of IO teamwork and its leadership is provided. Then follows an overview of relevant theoretical perspectives to the study of team leadership in IO settings. Next, central challenges regarding leadership of IO teamwork are discussed, and empirical examples of how leaders of IO teams go about managing these challenges are provided. Finally, directions for future research in this area are given.

INTRODUCTION

Teamwork is a core aspect of Integrated Operations (IO). This form of teamwork is typically of a complex nature, involving crossing of multiple boundaries: geographical, disciplinary, organizational, as well as cultural boundaries. What characterizes effective leadership practices in such complex teamwork settings is an area of considerable interest, for practitioners as well as from a research point of view. However, the extant literature on teamwork and leadership in IO settings is very sparse. There is currently only one academic reference specifically dedicated to the topic of leadership in IO, i.e., Skarholt, Næsje, Hepsø, & Bye (2009). Leadership in teams is an area that is receiving increased research attention, and progress has recently been made in the conceptualization of leadership functions in team settings (e.g., Morgeson, DeRue, & Karam, 2010).

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The concept of "IO teamwork" will be used to designate teamwork in IO settings.

The chapter starts by giving a brief presentation of the characteristics of IO teamwork and its leadership. Then follows an overview of relevant theoretical perspectives to the study of team leadership in IO settings. Next, central challenges regarding leadership of IO teamwork are discussed, and empirical examples of how leaders of IO teams go about managing these challenges are provided. Finally, directions for future research in this area is given.

WHAT CHARACTERIZES "IO TEAMWORK" AND ITS LEADERSHIP?

Due to the sparsity of the research on the topic, there is currently no consensus regarding what characterizes "IO teamwork." However, based on current knowledge, there are some typical traits that can be listed:

- Teamwork is regularly technology-mediated
- Team members have different and complementary competencies
- Team members are from different disciplines, cultures and organizations
- Safety implications are normally important in decision processes
- Some team members are regularly exchanged (typically offshore, depending on the shift schedules)
- They tend to comprise both onshore and offshore team members[1]

It should be clear from the definition above that leading such teams is of a comparatively high degree of complexity. "Leadership" is here defined as involving "intentional *influence* over others, through guiding, structuring and facilitating activities and relationships in a group or organization" (Thompson & Li, 2010, p. 16). There is little research available on how leadership of such teams differ from leadership of more traditional forms of teamwork. One of the informants in a study on which this chapter is based characterized leadership of IO teamwork in the following way:

In my view leadership of integrated operations is more related to things going fast. Otherwise it is much of the same. When you have the time for discussions and processes, you need to have completed those discussions and processes when you are gathered and need to make decisions…I think IO is very similar to other tasks. What is challenging is that people are sitting at different locations, one is sitting in different contexts, and we have the shift system with some working two weeks and having four weeks off. And then we the experts who are to give our contributions. That is an organzational challenge (discipline leader in charge of production optimization activities).

The purpose of teamwork in an IO mode is to take advantage of geographically distributed and multiple expertise in real time, supported by various technologies, to avoid the inefficiencies that often come with sequential collaboration, i.e., with team members contributing with their competence at different points in time.

This chapter will provide further details of particular challenges of team leadership in IO settings, with suggestions of how they can be managed. First, a review of relevant theoretical perspectives to the study of team leadership in IO settings will be provided.

RELEVANT THEORETICAL PERSPECTIVES TO THE STUDY OF LEADERSHIP OF IO TEAMS

As mentioned in the introduction, leadership of IO teams is an hitherto unexplored topic. In addition, there are several shortcomings in the existing research on team leadership in general. Despite

these shortcomings, there are several concepts and theoretical perspectives that can be assumed to be relevant for the study of leadership in IO teams, which will be presented and discussed in this chapter.

A Functional Approach to Team Leadership

Morgeson, DeRue, & Karam (2010) present a functional approach to understanding leadership structures and processes. They point out three main shortcomings in existing research on leadership of teams. First, past research has focused on a too narrow set of leadership activities. This has resulted in an incomplete account of the range of ways leaders can help their teams become effective. Second, empirical research has often relied on "traditional" leadership models in discussions of the role of team leadership. Traditional leadership models tend "not to make the distinction between leader-*subordinate* interactions and leader-*team* interactions" (Zaccaro, Heinen, & Shuffler, 2009, p. 84). Thus, there are considerable gaps in the current understanding of the unique interplay between teams and leadership processes (Kozlowski & Ilgen 2006; Zaccaro, Rittman, & Marks 2001; Morgeson, DeRue, & Karam, 2010). Third, Morgeson, DeRue, & Karam (2010) note, "extant research has tended to focus primarily on formal team leadership structures (i.e., hierarchical, formally appointed leaders). This has occurred despite the long-recognized fact that leadership is often distributed in a team (e.g., Bales, 1950; Slater, 1955). As is increasingly emphasized (Day et al. 2004, 2006), scholars need to focus on a broader array of leadership structures and processes within teams and not just the formal leaders of teams" (Morgeson, DeRue, & Karam, 2010, p. 2)

Thus, Morgeson, DeRue, & Karam (2010) propose a framework that integrates existing team leadership research and describe the wide range of ways in which leadership can manifest itself within a team. These authors then provide a framework of leadership functions, classified according to different sources of leadership. They divide teamwork into two distinctive phases the *transition phase* and the *action phase*. In the transition phase, teams engage in evaluation and planning activities designed to foster goal attainment. In the action phase, teams perform work activities that directly contribute to goal accomplishment. Over time, teams repeatedly cycle through transition and action phases.

In this framework, team leadership can be viewed as oriented around the satisfaction of team needs, with the goal of fostering team effectiveness. Whoever (inside or outside the team) assumes responsibility for satisfying a team's needs can be viewed as taking on a team leadership role. This is in line with functional leadership theory, which holds a prominent role among team leadership models. According to functional leadership theory, the leadership role is *"*to do, or get done, whatever is not being adequately handled for group needs*"* (McGrath, 1962, p. 5; Morgeson, DeRue, & Karam, 2010, p. 4). Team leadership is thus conceptualized as the process of team need satisfaction with the goal of enhancing team effectiveness.

In the framework developed by Morgeson, DeRue, & Karam (2010) there can be several sources of leadership in teams, both externally and internally to the team, and being both formal and informal.

A shortcoming with exant work in functional leadership theory is that it has had its main focus of attention on team needs, or functions, and devoted less attention to how specifically leadership can satisfy these needs. Thus, Morgeson, DeRue, & Karam (2010) present a set of key leadership functions that are necessary for team need satisfaction and team effectiveness (see Table 1).

Table 1. Team leadership functions (Morgeson, DeRue, & Karam, 2010)

Transition phase	Action phase
Compose team Define mission Establish expectations and goals Structure and plan Train and develop team Sense making Provide feedback	Monitor team Manage team boundaries Challenge team Perform team task Solve problems Provide resources Encourage team self-management Support social climate

Transformational Leadership and Situational Leadership Theory

Skarholt (2009) describe how the perspective of transformational leadership was applied to an asset at the Norwegian continental shelf called "Kristin." In the perspective of transformational leadership theory, leaders transform their followers' values, priorities, and goals to inspire followers to perform beyond expectations to serve the good of the larger group, organization, and mission. Transformational leaders articulate compelling visions that emphasize the meaning, importance, and value of goals, as well as the strategies for achieving those goals (Walumbwa, Aviolo, & Hartnell, 2010; Avolio, 2005; Avolio & Yammarino 2003). At the Kristin asset, introducing the concept of IO involved defining a vision and values regarding how the work should be performed, on the offshore installation as well as between the onshore and offshore personnel. The focus at Kristin was on empowerment, which was reflected in an autonomous style of work of the operators and a delegating leadership style (Skarholt, Næsje, Hepsø, & Bye, 2009).

Skarholt, Næsje, Hepsø, & Bye (2009) use situational leadership theory in their account of leadership at the Kristin asset. The fundamental assumption of this branch of theory is that different situations require different styles of leadership. At the Kristin platform the leadership style was characterized as "adaptive." Depending on the situation and discipline, it was found to be characterized by a participating, persuasive, or delegating leadership style.

The approach of Skarholt, Næsje, Hepsø, & Bye (2009) provides valuable insights into general leadership related to IO. However, the focus of these authors is not clearly on teams, but more on leadership-employee interactions and relations. This echoes Morgeson, DeRue, & Karam's (2010) criticism of existing team literature, namely that empirical research within this area has often relied on "traditional" leadership models when discussing the role of team leadership. As mentioned above, Morgeson, DeRue, & Karam (2010) point out that traditional leadership models tend not to make the distinction between leader-*subordinate* interactions and leader-*team* interaction. As a consequence, there are "considerable gaps in our current understanding of the unique interplay between teams and leadership processes" (ibid., p. 2). Transformational leadership would be a part of what Morgeson, DeRue, & Karam (2010) term "transition phase leadership functions", and more specifically what they term "define team mission".

Shared Leadership

Shuffler, Wiese, Salas, & Burke (2010) note that because of the complexity involved with ensuring effective team processes in geographically distributed teams, leadership behaviors may often need to be shared among team members. Shared leadership involves team members distributing leadership responsibilities among themselves, without excluding the possibility for vertical leadership. Shared leadership may be particularly important in geographically distributed teams, according to Shuffler, Wiese, Salas, & Burke (2010), due to separation between leader and team members which may necessitate a distribution of leadership functions. Shuffler, Wiese, Salas, & Burke (2010) argue that the sharing of leadership has emerged as a critical component in today's organizations, because of the continously changing conditions

of organizations that make sharing of leadership essential for their survival.

Shuffler, Wiese, Salas, & Burke (2010) use the already mentioned framework of Morgeson, DeRue, & Karam (2010) on leadership sources and functions to develop a set of propositions regarding the impact of virtuality and distribution on shared leadership. This fills a void in the Morgeson et al. framework, which does not address how the leadership functions will be affected by geographical distribution and virtuality (e.g., communication being mediated by technology). Salas, Rosen, Burke, & Goodwin (2009) point to preliminary research showing that shared leadership is more effective than traditional leadership structures. Thus, shared leadership may be an important enabler of team adaptability, another central dimension in the team effectiveness model of Salas, Sims, & Burke (2005) that is of high relevance to the concept of IO teams and their leadership.

Team Adaptability

IO teamwork happens in dynamic, shifting environments, as many unforeseen events can happen in the operation of oil and gas facilities, e.g., equipment breaking down in the production facilities, or problems arising during drilling operations. Therefore, IO teams need to be able to rapidly adapt to changing circumstances.

According to Salas, Rosen, Burke, & Goodwin (2009), adaptability within teams underlies many team functions and behaviors and can be characterized "as the team's ability to change team performance processes in response to cues from the environment in a manner that results in functional team outcomes" (ibid., p. 43). Salas et al. point out that adaptability is an essential component of teamwork, particularly for teams working in dynamic conditions.

Burke et al. (2009) point out that researchers only recently have begun to examine the antecedents, processes and emergent states that constitute adaptive team performance, and leading to team adaptation. In a model of team adaptation, Burke et al. (2006, p. 1190) conceptualized team adaptation as "a change in team performance, in response to a salient cue or cue stream, that leads to a functional outcome for the entire team and is manifested in the innovation of new or modification of existing structures, capacities, and/or behavioral or cognitive goal-directed actions" (quoted in Burke et al. 2009, p. 211).

Thus, leadership of IO teamwork needs to be seen in relation to the concept of team adaptability, as this is an important characteristic for IO teams. The concept of team adaptability points to a related concept, that of "self-synchronization."

Self- Synchronization

"Edge organizations" and "self-synchronization" are other relevant concepts to leadership of IO teams. The Edge of the organization is where the organization interacts with its operating environment to have impact or effect on that environment (Alberts & Hayes 2005), and where the organization creates or expends value. In Edge organizations performance data are typically more visible. However, experience has shown that visibility of performance data at the edge does not mean the 'centre' takes more control. In fact, Hepsø & Gramvik (2011) point out, the opposite has proven to be the case. The reason for this is that as the observability of the information gives the centre the confidence to allow decisions to be made at the appropriate level in the organization, i.e., at the edge of the organization. This approach allows the organization to move away from coordination from the centre, which becomes increasingly difficult at the global scale and complexity of an organization grows, to a "self-synchronised" model based on shared situational awareness.

Shared situational awareness refers to the degree to which team members possess the same situational awareness or shared mental models (Skarholt, Næsje, Hepsø, & Bye, 2009). Shared

mental models are organized knowledge structures that facilitate execution of interdependent team processes (Salas, Rosen, Burke, & Goodwin, 2009). According to Salas, Rosen, Burke, & Goodwin (2009, p. 45), "a mental model that is shared is a knowledge structure or mental representation that is partially shared and partially distributed throughout a team. This 'sharedness' or distribution allows team members to interpret incoming information in a similar or compatible manner and thereby facilitates effective coordination." Salas, Rosen, Burke, & Goodwin (2009) point out that teams where team members share mental representations are better able to achieve effective and adaptive team performance and higher quality of decision making. The reason for this is that "Team members that share mental representations are better able to develop similar causal explanations of the environment as well as inferences about possible states in the environment in the near future" (ibid., p. 45)

Hepsø & Gramvik (2011) define self-synchronisation as the capability to empower those at the edge of an organization to operate as autonomously as possible and have the ability to plan and execute their tasks based on shared situational awareness. Hepsø & Gramvik point to three conditions that need to be in place to have shared situational awareness:

- **Quality Real Time Data and Information:** It must be the same data and the same time and be available to any who can potentially add value to any decision made based on the availability of the data
- **A Mutual Understanding or Shared Mental Model:** All parties must be fully aware of all current and historical events leading up to the value adding decision that is being made. All parties must also understand the overall strategy and priorities and changes in these in the run up to a decision being made
- **Trust:** All parties must trust and understand each other. They must know each others' strengths and weaknesses.

Self synchronisation requires a move away from the instructive command and control management style that has been common in many organisations to a more supportive and less controlling model (Hepsø & Gramvik 2011). I.e., towards more team self-management, one of the leadership functions in the action phase of Morgeson, DeRue, & Karam (2010).

LEADERSHIP CHALLENGES OF IO TEAMWORK: HOW CAN THEY BE MANAGED?

This part of the chapter will present empirical findings of how leaders of IO teams go about managing the challenges of IO teamwork, linking these findings to the concepts and theoretical perspectices that were presented in the previous section.

The main source of these empirical findings is from a small-scale exploratory interview study on IO leadership. This study includes qualitative, semi-structured interviews with ten informants coming from four different international oil and gas companies operating on the Norwegian continental shelf. The informants in this study are of two separate categories: persons in formal leadership roles, as well with persons in advisory roles who are involved in team, organization, and leadership development in their respective organizations. The latter category was chosen as they bring valuable outsider's perspectives to the challenges of leading IO teams, and how to manage them. Seven of the informants were in leadership roles, while three were in advisory roles. A shortcoming of this study is that it does not include the views of onshore and offshore team members without managerial responsibilities. The small number of interviewees also limits any generalizing potential of the study.

In addition, this section relates findings from the above-mentioned exploratory study to findings from other qualitative studies of IO teamwork that have been conducted in different oil companies, concerning challenges of IO teamwork. Findings from these studies are presented in Guldemond (2011), Guldemond, ten Have, & Knoppe (2010), Kaarstad, Rindahl, Torgersen, & Drøivoldsmo (2009), Rindahl et al. (2009), and Skjerve & Rindahl (2010).

Facilitating Self-Synchronization and Team Adaptability

Self-synchronization was mentioned in the previous section as important, and the concept of shared situation awareness was linked to this. Team adaptability was also brought up as a closely related concept. IO teamwork is typically highly coordination intensive, necessitating coordination between numerous geographically distributed actors due to multiple interdependencies. Thus, the concept of dependency awareness seems fitting to such teamwork contexts. To talk about dependencies in relation to coordination is nothing new. However, the concept of dependency awareness in studies of coordination is new, and in an IO context this is particularly important. Integrated operation is about linking people with the needed competence together at the same time, using information and communication technologies to support this. A prerequisite for knowing who to connect together and when requires a dependency awareness, or an awareness of interdependencies, to be able to achieve effective coordination with regards to the problem that is to be solved by the people meeting together.

In addition to the concept of dependency awareness, there is some evidence supporting that the concepts of shared leadership (see e.g., Shuffler, Wiese, Salas, & Burke, 2010) and team self-management are important aspects of leadership of IO teams, team self-management being one of the functions included in Morgeson, DeRue, & Karam's (2010) framework of team leadership functions.

Normally there is quite a high degree of coordination complexity in the collaborative technical problem solving between onshore operational support staff and offshore installations, due to the simultaneous spanning of many boundaries (geographical, functional, organizational, and cultural). To improve coordination between onshore and offshore and between functional areas, an oil company had established an integrated operations and maintenance team to ensure that people were able to talk directly to one another within an informal arena, over a coffee cup, and in arenas where the leader also was present. Previously the operations and maintenance teams had been organized separately from one another, which created a set of challenges related to communication and coordination. The purpose of creating such an arena was to facilitate informal comunication, but also to ensure that they got a more formal session after the informal one such that coordination was supported by a governed system. The intention was to have people sitting talking together, and communicate directly to decide how to solve their tasks after the daily video meetings in the morning, because of the coordination complexity involved in daily tasks:

Even though people have agreed about what needs to be done after the regular morning meetings, there is a lot of coordination that needs to be done. For example, if we should do it now or after the coffee, in the morning or after lunch. That is, to get to know when it fits with people's schedules. The intention was to get this type of communication between the people who were in charge of doing the job, of things were to be done, and the sequence of things, without the leader dictating how things were to be done. The manager did not need to be in the dialog, but it could be an advantage if he was present in the room so that he could enter the dialog if he wanted to (platform manager).

Thus, informal communication is needed for the people involved to develop the degree of dependency awareness that is needed to be able to coordinate their work effectively. Another statement from the same platform manager may illustrate the relevance of the concept of dependency awareness:

For example, that a lamp in the roof over a valve needed to be shifted before one could do the reparation of the valve. And when you were to go through activities, it appeared that someone else were to work in the same area. Then people were able to agree that first the lamp in the roof needed to be shifted so that the person that were to do work on the valve had good light conditions for doing work afterwards, and that nothing would fall into the head of the person that was to do work on the valve. This were the kinds of things that no planners could have predicted, but that the team was able to spot right away. The task of the leader was to facilitate an arena and circumstances to get the dialog going in the team. The team had a job, and started talking about it, not the leader.

Another dimension of dependency awareness can be that it helps foster commitment among team members to perform their job well. By highlighting the importance of individual contributions in the solving of coordination-intensive problems, the platform manager mentioned above sought to emphasize how achievements were made possible by all parties involved. This, in his view, created in team members an attitude of *"*I will be an important contributor in this, because they depend on me.*"*

There may also be another way that IO teamwork may stimulate to the formation of shared commitment, or shared responsibility in a team:

It is important to contribute with the insights and competence you have when the issues are ongoing. To come afterwards, or in too long sequences, makes you lose the contents, the punch, and the creativity, because things happen at different places and at different points in time, and you don't know if you have perceived the premises in the same way. All variables should be brought forward at the same time. That is the only way to get an overview, and to get all to assume a shared responsibility. If you are invited into a decision making situation where all the people involved are located, it becomes easier to assume a shared responsibility (advisor).

Shared responsibility, as mentioned in the quote above, can be viewed as a dimension of "emergent states" in the model of team adaptation of Burke et al. (2009). The above quote is also an illustration of how teamwork in an IO mode is particularly well suited for building shared situation awareness in a team, the latter being a concept which is often used in the IO area.

The following account on how a technical problem at an offshore installation was solved provides a good illustration of how IO teamwork can build shared situation awareness, and its impact on team outcomes. A mechanic at the offhore installation in question had been having problems with a pump for ten years. There had been many maintenance leaders and many operations people involved in maintenance and change of the pump, but it kept having regular problems. Therefore, they decided to try a different way of approacing the problem, by putting a mechanic who was not particularly fond of technology-mediated communication and put him in front of a videocamera to get into videomeetings with support people onshore. They had taken photos to show what he was doing when changing the pump. An engineer onshore was participating at the other end, and the leaders were only participating as facilitators. Pictures were taken, the meeting was set up, the leaders were only the "oil in the machinery" at the side, to use the terms of the platform manager providing this account. The

mechanic was communicating directly with the engineer, and they were collaborating directly via videoconferencing to make the pump work. The mechanic explained directly to the engineer how they normally installed a pump after repair. The engineer then went to a meeting in Germany to the pump manufacturer, and the discipline responsible mechanic from the offshore installaton joined this meeting. Previously, only the onshore engineer had been at these meetings without any offshore mechanic joining him. With both onshore and offshore people joining the meeting together, the German manufacturer was able to detect the error causing the problem with the pump. An old form of leadership and organization had attempted to solve this problem for ten years. With the leader getting a new role, he just linked people together and let them communicate, without controlling anything directly.

It can be assumed that the above-mentioned way of solving the problem facilitated a shared situation awareness of what constituted the problem, which enabled the oil company people along with the pump manufacturer to find a solution that finally worked. Shared leadership and team self-management were core aspects of how this particular technical problem was solved. Thus, to build the team's ability to coordinate effectively and self-synchronize, in the complex and dynamic contexts of IO teamwork, shared leadership and team self-management are important, as the following statement may illustrate:

If you are to have a good process for collaboration at a distance, it needs to be self driven. If you are to do things, then the processes should be so good that the leader doesn't need to be there. Then I make myself superfluous…I am proud when I hear that they have had a collaboration meeting without the leader being there. When a work process goes without it being leader driven, then you know that this process is really good. An important task for the leader is to 'oil the machinery', and when things become self reinforcing things go by themselves (platform manager)

An operations manager also considered the concept of shared leadership to be relevant for her IO team:

Shared leadership fits well with how leadership is conducted in the collaboration between onshore and offshore. The planners have task responsibilities and are to lead the planning processes. They need to behave as clear leaders in the planning meetings. The O&M managers have personnel responsibilities for process, mechanical, and automation.

"Intention-based leadership" was another term that came up in the interview study on which this chapter is based. A person working in an advisory role within team and organization development in an oil company described this form of leadership in the following way:

If you are to realize the maximum capacity of the individual, you must not enforce limitations. You must provide opportunities by putting it into the context of the whole, where they understand how they bet can contribute. If you put regulations into that context you have put the organization into a completely different state, where you already at the outset clearly define the frames for what is to be delivered. When it comes to behavior to get an optimal team structure to get the speed of the solution to increase, I am more inclined towards stimulating the organization concerning the choice of leadership methods. I think that the approach of intention-based leadership to a certain level within this team structure is the right way. This stimulates proactivity. Proactivity comes when you maximize your abilities early and everywhere to be able to solve a problem before it occurs.

Such intention-based leadership can be assumed to be instrumental for self-synchronization and team adaptability.

Kaarstad, Rindahl, Torgersen, & Drøivoldsmo (2009) point out that in a complementary work environment like an IO team more focus needs

to be placed on the relation between participants, as a large proportion of the tasks in an IO setting are complex in nature. The latter authors state that "the task for the team leader in such a setting will not be to stimulate one person to contribute with his talents and his views, but to make the other persons in the team understand the contribution and to utilise this in the further interaction and teamwork" (ibid., p. 4)

Skjerve & Rindahl (2010) point to empowerment, i.e., team self-management, as particularly important for leaders of IO teams, emphasizing the following aspects: facilitating decision making at the right level by encouraging team members to take over when relevant, and distributing the responsibility for preparing and using collaboration technology, so that all team members obtain the needed competence.

Næsje, Skarholt, Hepsø, & Bye (2009) describe shared leadership at the Kristin asset, and how it was shared between the management team and the Operations and mainternance (O&M) supervisor. The latter was the first line leader of the O&M crew, but management was performed by the entire management team. Management was not involved in solving all technical questions, but was involved in giving priority to which tasks that were to be solved. In addition, management coordinated between functions when necessary, and between technical support, contractors, and the O&M crew when necessary. The management style in the asset was focused on developing capabilities, empowering operators on the one hand, and supporting self-synchronization on the other.

However, empowerment and self-synchronization do not imply that leadership in IO is subject to no contingencies. Oil companies typically have defined and standardized work processes:

We have implemented common, or standardized, work processes…in our company. When roles and responsibilities are defined in the work processes, you make it very clear what requirements and expectations that are to be met. And this is something that a leader needs to be familiar with. He must know not only what is his responsibility, but how roles and responsibilities are distributed in the team (advisor).

The need for empowerment on the one hand, and structures on the other hand, might create a potential source of tension for teams, and there will be a need to strike a balance. The same advisor as in the quote above expressed this in the following way:

When we talk about standardization it is at a quite overarching structural level. We are talking about a framework within which there are quite large degrees of variation. There are many possibilities for adaptation. But it is a line of balance. Within such systems one must be very conscious that one does not go too far in describing how everything is to be done. That the focus is on demands, what is principally fundamental to consider, regarding health, safety and environment, in particular, and who is to be involved.

There is also a balance that needs to be struck between a permissive and empowering leadership style and a more directive leadership style, as illustrated by the following quote:

The problem is that if you are too inclusive, inviting, and listening, you might get into a situation where you become hesitant and unclear. You need to get into the arena, to join the 'game.' You need to challenge yourself to listen to the other competent people and invite them into the discussions. At the same time, one cannot fail one responsibilities as a leader, to say 'now we don't have more time, we need to do like that.' To be a good leader in an IO setting is to balance, to be able to say, 'now we have exploited the time at our best, now we have had as much information as we can put on the table, and all important stakeholders have been given the opportunity to participate. Now we must make this decision together.

This quote may be understood from the perspective of situational leadership theory, which states that leadership style needs to be adapted. According to this theory, there is no single universal style of leadership that is best for all circumstances. Thus, leadership style needs to be matched with the development level of followers. "Situation" in this theory refers to several aspects: the attitude of followers, the behavior, values, and requirements of colleagues, the company culture, and taks attributes (Thompson & Li, 2010).

To sum up, the concepts of shared leadership, dependency awareness, team self-management, and self-synchronization are closely related. Team self-management and shared leadership enable dependency awareness, enabling self-synchronization, that in its turn enable team adaptability. Shared commitment, or responsibility, among team members are also highly probable contributing factors to team adaptability. As mentioned, IO teamwork happens in dynamic, shifting environments, with many unexpected technical problems arising. To solve such problems it becomes necessary to be able to rapidly link the needed expertise together. And this expertise is normally located at separate locations, coming from different disciplines, and often different organizations. To be able to rapidly solve such unexpected problems, it is evident that self-synchronization is an important attribute. And shared leadership, team self-management and dependency awareness among team members can be seen at preconditions for teams being able to self-synchronize. The concept of shared situation awareness has been used frequently within the IO area. Shared situation awareness is also a precondition for a team's ability to self-synchronize. This section has put emphasis on the concept of "dependency awareness" as an important addition to the concept of shared situation awareness. In this concept awareness does not necessarily have to be shared, but it is an important prerequisite for effective coordination. An illustration of how a platform manager helped to facilitate dependency awareness to nurture a sense of commitment among team members was provided. Finally, it was emphasized the need for leaders in IO settings to be able to balance several needs or requirements. IO teams do not operate in a vacuum, but are integral parts of organizational contexts and governance structures. The following section delves into the challenges of IO team leadership in matrix organizational structures.

IO Teamwork in Matrix Organizations

IO teams typically operate in matrix organization structures, i.e. where team members report to two leaders at the same time. It is well known that the matrix form of organization comes with a set of challenges (Galbraith 2008), further adding to the complexity of IO teamwork. As described by a discipline leader for production optimization:

We formal leaders are leaders for some of the people present in the collaboration meetings. So in a way it's an organization with very many leaders who are responsible for bits of the people who are meeting. The platform manager is responsible for the control room operators, the operations manager is responsible for those representing the operatons support group, and the petroleum technology and production engineers report to me. So a production optimization group does not have one leader, but several leaders. And in addition, there is a defined facilitator for the group.

This particular aspect of IO teamwork encompasses all of the functions in the Morgeson et al. (2009) model.

Guldemond (2011), in his studies of Collaborative Work Environments (CWEs) in an international oil company, demonstrated the challenges that this organizational structure entail for "CWE teams", or what is termed IO teams in this chapter. Guldemond et al. (2010, p.2) define a Collaborative Work Environment (CWE) as "A forum, which is specifically created to integrate people, processes, technology and facility for improved

cross-functional and virtual collaboration, learning and high quality and fast decision-making." There are particular challenges for a team leader within such a structure (Guldemond, ten Have, & Knoppe 2010). A CWE team leader is responsible for integration between the different disciplines involved in a CWE. One challenge is that a CWE team leader has no formal authority over staff of different disciplines involved in the CWE, as the formal authority resides in the leaders of the disciplines. When priorities are competing, Guldemond, ten Have, & Knoppe (2010) found that preference is given to develop functional specialization, instead of executing processes. This points to an organizational tension, or dilemma, between functionally based organizations and process-based organizations (Guldemond, ten Have, & Knoppe 2010).

Guldemond, ten Have, & Knoppe (2010) point to unsolved human factor issues in CWEs: "Working in Collaborative Work Environments cuts across traditional disciplinary and geographically dispersed boundaries. Less hierarchical reporting relationships and multidisciplinary teams replace clear-cut single hierarchical reporting relationships and single-disciplinary teams. The new way of collaborative working calls for supporting organic organizational structure for the CWE" (Guldemond, ten Have, & Knoppe 2010, p. 2).

One possible way of solving this problem, suggested by Guldemond, ten Have, & Knoppe (2010), is to put the CWE team leader at the same hierarchical level as the heads of discipline in the Operating Unit. Such an arrangement would provide the CWE team leader formal authority for the executing processes. In Guldemond et al.'s suggestion, placing a CWE team leader at the same hierarchical level as the discipline heads would provide "a better balance between developing functional specialization (functional line) and executing processes (process line)…" (Guldemond, ten Have, & Knoppe 2010, p. 8).

It is typical for petroleum companies to have functional reporting lines, a characteristic that can be a constraint to cross-functional collaboration. A related problem is that performance appraisal systems do not reward cross-functional collaborative behavior in CWE team settings (Guldemond 2011; Lameda & Van den Berg 2009). Guldemond (2011) identified the need for organizational restructuring to enable teamwork in in CWE settings, and found support for this claim in a study of several CWE teams in an international oil company. Without changing the production structure of an Operating Unit difficulties will occur with the integration of the Operations and Petroleum Engineering Groups in the control structure of a CWE, Guldemond (2011) argues. In his case studies Guldemond (2011) found that for CWEs focusing on well and reservoir management, organizational design changes were needed, and this was done through implementing integrator roles and departments, as well as matrix organizations.

Guldemond argues that the full potential of CWEs will not be realized as long as the petroleum industry continues to perceive the functional organization as the best organizational design for CWEs. In addition, there is a belief that these organizational design challenges will be solved by having people sitting in close proximity to one another. Further, Guldemond (2011, p. 246) states that "by simply providing communication tools (for example videoconferencing) without making organizational changes, many managers continue to perceive the installation of CWEs as primarily a technological challenge." As long as the petroleum industry continues to perceive CWEs primarily as a technological solution, the coordination challenges of CWEs will not be resolved, Guldemond (ibid.) argues. In other words, having a matrix organization structure such as CWE teams in a functionally based organization can prove challenging to team adaptability and self-synchronization.

The following are statements from persons with leadership functions in IO teams regarding how to manage challenges related to multiple leaders in a matrix organization:

It is important for the leaders to be coordinated, so that we are speaking with one voice to our employees. That is, me, the platform managers, and the O&M managers (operations manager).

It is important for the management team to talk so well together that we know what we actually mean. That we really agree down to the comma sign, that we fully agree on what we are to achieve. Then you create a sense of confidence in the management team that will spread further in the organization….It is the process of discussing things through, to agree on things, that is the important part. In our organization the management team was very well coordinated. We worked our way through discussing things through to build a mutual understanding in the management team of how things were to be done. In this way, you get the same answer from your leaders whoever of them you ask. That removes frustration (platform manager).

The leaders in the organization mentioned in the citation above were all located in Norway, and they were all Norwegians. However, if team members report to functional leaders who are dispersed across several countries and continents, as is the case in many international oil companies, it can be assumed that achieving such coordination will become more challenging. This is because communication then will become more of a challenge due to language and culture differences, time zone differences, in addition to having to rely on technology to communicate. Thus, to what degree matrix organization poses a challenge for leaders of IO teams may depend on the degree of geographical distribution of the functional leaders to whom team members report. In addition, the formal authority given to the IO team leader role will also probably influence on how challenging this organizational structure will be experienced for an IO team.

Meeting Leadership Skills

IO teamwork involves a high degree of complexity, and needing effective coordination among geographically distributed team members, coming from different disciplines, cultures, and often different organizations. Much of the coordination takes place in videoconference meetings which can be quite complex, with multiple locations connecting to a videoconference, and information being shared on a shared surface to all locations participating. In addition, there will typically be several people at each of the locations involved, making it impossible to see facial expressions clearly for a meeting leader. Meeting leadership skills naturally becomes important in such settings. The following are statements illustrating how leaders of IO teamwork manage the challenges related to such distributed meetings:

In leadership at a distance I need to be more questioning in the communication. You often get little information regarding body language and facial expressions when you have 5-6 people offshore participating in a videoconference, as you then need to zoom out the picture to get everyone included in the picture. Then you don't see any faces clearly (Operations manager).

I don't think national culture plays that big a role in discipline matters, it has mostly to do with how you behave in meetings, and what you can permit yourself to do concerning jokes and things like that. You should be careful with making casual remarks if you don't know people, then people can easily be hurt. Or what you say can be perceived differently from what you intended (Operations manager).

You get better contact face to face, you get the body language as well. You should be careful with making jokes in a videconferencing meeting. You might offend people in a way that you are not

aware of. If you did so in a colocated meeting you would see if people did not perceive it in the same way. You need to be a little more formal in a videoconferencing meeting than in a colocated meeting (Operations manager).

There are many poor videomeetings where the people with leadership functions only have two-way dialogues with a few selected people in the meeting, ignore that there are people present who are not required in the meeting, and do not sum up clearly what has been decided. In such virtual spaces it is important to be a little conscious that people have understood and received what you have said, that you point at data you are talking about to be sure that everyone understands what you are pointing at.

These quotes provide illustrations of the importance of skills in running virtual meetings for persons with leadership responsibilities of IO teams.

A longtitudinal study of IO collaboration at the Brage asset in Statoil identified several characteristics of good meetings leadership skills (Rindahl et al., 2009):

- Create a good start of the meeting
- Verify that all participants can see the same interaction surface
- Be clear but not too dominating
- Keep an overview of all roles presented
- Involve and encourage the participants to give input – both in the same room and in the other room
- Listen to the participants and follow up issues that are raised
- Keep the meeting focused and intervene if necessary

Rindahl et al. (2009) state that a good meeting is chaired with "a delicate balance between efficiency and meeting participation. If chairpersons are too visible over too long time, an output could be a construction of power that is not necessarily wished for, and not productive for the interaction and collaboration. In an IO setting it is important that persons are involved and it is therefore important to encourage the participants to pass the ball further" (ibid., p. 25)

Further, Rindahl et al. (2009) emphasize the importance of a meeting leader to be involved, ask questions and listens to, coordinates and emphasizes the participants' contributions. Such behaviors will stimulate a good quality of discussions as well of decisions.

Based on the same study mentioned above, the following advice was formulated by Kaarstad et al. (2009, p. 4): "The meeting leader should be prominent, but not too dominating, focus on involving *all* participants and encourage them to contribute. The leader must also keep the meeting focused and follow the agenda, and clarify issues through frequent summaries and noting of actions."

Trust-Building Leadership

In the previous section on extant research and theory relevant to leadership of IO teamwork, trust was mentioned under the heading of self-synchronizaton, referring to Hepsø & Gramvik (2010). Skjerve & Rindahl (2009) point out the challenges and importance of trust in IO teams. In their studies of IO teams they identified an awareness that promoting trust in their teams was necessary and important. Trust was seen as a prerequisite for team members to be willing to listen to and share information with one another. The trust concept is defined differently across social science disciplines. A general definition that covers different ways of conceptualizing trust is the following: "…a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another" (Rousseau et al. 1998, p. 395; quoted in Julsrud 2008, p. 22). Furthermore, there are cognitive and affective dimensions to trust. The

cognitive dimension refers to calculative and rational aspects of trustees, e.g., reliability, integrity, competence, and responsibility. Affect-based, or emotionally oriented, trust refers to such aspects as the social skills of trustees (Julsrud 2008).

Skjerve & Rindahl (2010) identified two sets of factors promoting trust in IO teams: organizational factors, and factors at the individual level. Among organizational factors they include promoting familiarity between members of IO teams, establishing sound work processes, and ensuring that technology adequately facilitates IO teamwork. As examples of individual factors promoting trust they point to three types of individual competencies that should be trained: disciplinary competencies, technology literacy, and teamwork competencies.

The following statement from an operational manager adds a further dimension to factors contributing to trust building in IO teamwork: the ability of a leader to coordinate and steer the contributions from multiple persons working in the onshore operational support organization into high-quality advice given to an installation:

You need to build respect, so that people trust you and know that what comes from you is sensible. Then it works easily. You need to be able to build your team so that everyone works on to establish a recognition and trust so your organization represents an integrity and an ability to create and establish the trust and confidence that you need in the organization to make things happen. This might be one of the big challenges in such an integrated operations team, where everyone can contribute, and where you can steer the information so that what comes out is of quality. That not everyone comes flying in with contributions, but that you are able to steer it in a way to ensure that the output is of quality, that the contributions coming are not haphazard. Because that can happen in such an environment, that everyone, every discipline come with their views on how they want things to get done, and send it on to the shift leader [at the installation]. And then comes another view from another. To get coordinated contributions that are integrated is a challenge in such an environment.

Another operation manager pointed out the topic of trust in the following statement:

The most important collaboration skills are to respect one another's competence, to have trust that everyone who one is working with has something to contribute. People are different. Some are more open and sharing. Others need to get to know people better to do the same.

Another method from a platform manager to contribute to rapid building of trust in collaboration between people onshore and offshore who have not met before.

A leader must see to that the dialog is flowing. When we are to have a collaboration meeting where the parties have not met before you need to have a presentation round.

This platform manager had a practice where he made the expertise of the parties involved known to each other. As a leader he had the practice of actively telling the parties involved what they were good at.

I don't get them to boast of themselves, that I as a leader must enter and do. Then the mutual respect suddenly starts. 'He knows a lot about that, and he knows a lot about that.

However, the same platform manager had found it difficult to get presentation rounds in this format, so he had found another way of arranging collaboration meetings.

I get the people onshore to tell something that I know that they are good at. Then I as a leader must have been a part of the networking, in the new organization that I am to enter and find out what he is good at, and what he is doing in his spare time.

Thus, trust is a multifaceted concept, and there can be many ways for a leader in an IO teamwork setting to go about promoting the establishment and maintenance of trust in a team.

Change Management Competence

IO teamwork has become the normal way of working in several oil companies, but for many others it will constitute a new way of working. Introducing such a form of teamwork into an organization will necessarily imply efforts with change management.

Transformational leadership in teamwork will probably be particularly important when introducing new ways of IO teamwork, and in relation to the following leadership functions in the transition phase of the Morgeson, DeRue, & Karam (2010) framework: defining mission, establishing expecations and goals, sense making, and providing feedback.

Some provocation and humor can maybe be effective to increase willingness of team members in using IO solutions in team collaboration. A platform manager put it this way:

There will always be resistance to change, we want to keep doing things the way we have been doing. 'Great', I use to say, 'then you can keep on driving around in your old Ford Escort or Lada on that humpy sand road.' We would like to keep what we consider safe. What you see with IO is that we become so much more visible and transparent in everything we do. So if we make a mistake, it is visible right away. That makes us struggle a bit in using the new opportunities that we have in a better way, I think. We have really become very vulnerable.

An operational manager pointed out situational leadership as useful when introducing new technologies to support IO teamwork:

The leadership style is situation dependent, you have to play on several strings. As a leader you need to show the possibilities with new collaboration solutions, start to use them yourself, and ask for the solutions to be used. Sometimes you need to communicate more clearly that 'this is the way we are going to do it.

Lilleng & Sagatun (2010) point to the importance of establishing the right frame of mind, or an "IO mindset", as a key success factor for IO. According to these authors, "a sustainable change and continuous improvement attitude is and will be achieved by having a continuous change management focus in the organization." Lilleng & Sagatun (2010) argue that the 8-stage change management model of Kotter (1996) must be in place to cultivate an "IO mindset."

Edwards & Mydland (2010) also point out central aspects of change management related to IO implementation (or "intelligent energy" as they call it). According to Edwards & Mydland, a good combination of leadership at all levels in the organization is needed to achieve an effective implementation of IO/iE. These authors do not mention teamwork explicitly, but this is an inclusive part of what is called IO and iE, so teamwork is also included in this.

FUTURE RESEARCH DIRECTIONS

Research in this area is merely in its early beginnings. This chapter has provided a number of insights into what dimensions are important in the leadership of IO teams. However, the empirical basis for these claims are very limited. Much more knowledge is needed into the specifics of what leaders of IO teams can do to effectively lead such teams. For example, Hepsø & Gramvik (2011) point to that leadership in "Edge organisations", of which IO teams are an example, can

be challenging for those who have been brought up in more traditional "command and control" organisations. Thus, an important task for coming research on leadership of IO teamwork will be to investigate what leadership qualities are needed to lead an Edge organisation, as well as methods and training programs for developing these new leaders (ibid.).

Morgeson, DeRue, & Karam (2010) state that sources of leadership can be both inside and outside the team. In the section on matrix organization we have seen that leaders outside IO teams can impact on a team's ability to integrate across functions. Thus, another area in need of more research is how people in leadership functions outside of an IO team impact on the internal processes of an IO team, in both positive and negative ways.

There seem to be several advantages to the Morgeson, DeRue, & Karam's (2010) framework to which this chapter has referred frequently, in addition to the advantages emphasized by the authors themselves. One clear advantage is the fine-grained nature of the framework, compared to leadership concepts such as "transformational leadership" and "situational leadership", which are at a more abstract and ambiguous level. However, there also is need for further research to identify possible shortcomings in this framework with regards to IO teams. We have seen that parts of the framework fits, but further research is needed to identify how well this framework for team leadership fits the IO team context, and how it might have to be adjusted to fit the context of IO team leadership.

There is also need for more research into how central concepts in this chapter fit into the Morgeson, DeRue, & Karam (2010) framework. Transformational leadership would fit certain of the functions in the transition phase, i.e., define mission, establish expectations and goals, and sense making in particular. Situational leadership would fit all functions in both phases, except the "compose team" function. Matrix management relates to all functions. The same is the case with the "dependency awareness" concept. Self-synchronization is a particularly important aspect of IO teamwork, which also relates to several of the functions in this framework.

Another area where further research is needed is on how trust influences effective IO teamwork, as well as how it can be established and maintained. Skjerve & Rindahl (2009) point to a need for studying management trust towards their subordinates. These authors (ibid.) argue that to ensure that a decision is made at the right level, higher level managers need to trust their staff with these decisions. Thus, more knowledge is needed about how leaders develop this type of trust and how they best make it visible to the staff members.

National cultural differences in IO teams in relation to team leadership is also an area where further research is needed. International oil companies have a multicultural workforce, and their IO teams are also frequently of a multicultural composition.

The concept of "multiteam systems" (MTS) appears to be relevant the the IO context. This refers to a system of teams where several teams need to coordinate in relation to one another. MTS refers to two or more teams that interface directly and interdependently in response to contingencies in their environments toward the accomplishment of collective goals. According to DeChurch & Zaccharo (2010, p. 329-330): "MTS boundaries are defined by virtue of the fact that all teams within the system, while pursuing different proximal goals, share at least one common distal goal; and in doing so exhibit input, process and outcome interdependence with at least one other team in the system. The problem of external alignment among teams comes clearly into focus when one considers the unit of analysis to be the MTS." From a MTS perspective, instead of focusing exclusively on how individuals combine synergistically to perform as a team, the focus is on how teams that often come from multiple organizations combine

together to perform as a system (DeChurch & Zaccharo, 2010). The concept of multiteam systems points to the need for coordination across multiple teams. Leadership within such MTS arrangements is probably of quite a high degree of complexity, and will be an important research task in future research of leadership in IO settings.

CONCLUSION

This chapter has provided a glimpse into leadership of teams in an integrated operations setting, or "IO teams" as they have been termed here. Relevant concepts and theoretical perspectives have been discussed, as well as examples of challenges related to leadership of IO teamwork and how the challenges can be managed.

In relation to the model of foundational capabilities described in the introductory chapter, leadership of IO teamwork can be conceptualized as consisting of four core aspects: Technology, people, process/governance and organization. Regarding technology we have seen the importance of technology literacy for leaders of IO teams. The people aspect permeates all sides of IO leadership. Process/governance was dealt with concerning matrix management, and how governance rights of leaders outside of an IO team can constitute a challenge for effective IO teamwork. The organization dimension also permeates all aspect of IO leadership as all leadership activities take place within organizational contexts.

The chapter has pointed to several areas in need of future research. This will build a more solid basis to identify appropriate terms for the types of leadership that fit within these contexts. This chapter has pointed out some terms that are relevant, e.g., transformational leadership, and situational leadership. In addition, other terms will be needed. One such term might be "netcentric leadership." Another might be "boundary-spanning leadership", as IO is about crossing multiple boundaries, geographical, disciplinary, organizational, and often cultural boundaries. Hopefully, this chapter has provided some indications to many opportunities for future research that can bring the area of team research forward into exciting realms.

REFERENCES

Alberts, D. S., & Hayes, R. E. (2003). *Power to the edge, command and control in the information age*. CCRP Publication Series.

Avoilo, B. J. (2005). *Leadership development in balance: Made/born*. Mahwah, NJ: Erlbaum.

Aviolo, B. J., & Yammarino, F. J. (Eds.). (2003). *Transformational and charismatic leadership: The road ahead*. New York, NY: Elsevier.

Bass, B. M., & Avolio, B. J. (Eds.). (1994). *Improving organizational effectiveness through transformational leadership*. Thousand Oaks, CA: Sage.

Burke, C. S., Priest, H. A., & Wooten, S. R. Diaz-Granados, D., & Salas, E. (2009). Understanding the cognitive processes in adaptive multicultural teams: A framework. In E. Salas, G. F. Goodwin, & C. S. Burke (Eds.), *Team effectiveness in complex organization. Cross-disciplinary perspectives and approaches.* New York, NY: Routledge.

Day, D. V., Gronn, P., & Salas, E. (2004). Leadership capacity in teams. *The Leadership Quarterly*, *15*, 857–880. doi:10.1016/j.leaqua.2004.09.001

Day, D. V., Gronn, P., & Salas, E. (2006). Leadership in team-based organizations: On the threshold of a new era. *The Leadership Quarterly*, *17*, 211–216. doi:10.1016/j.leaqua.2006.02.001

DeChurch, L., & Zaccharo, S. (2010). Perspective: Teams won't solve this problem. *Human Factors*, *52*, 329–334. doi:10.1177/0018720810374736

Edwards, T., Mydland, Ø., & Henriquez, A. (2010). *The art of intelligent energy (iE) – Insights and lessons learned from the application of iE*. SPE paper no. 128669. Paper presented at Intelligent Energy Conference, Utrecht, Netherlands, 25-27 February 2010.

Galbraith, J. (2008). *Designing matrix organizations that actually work: How IBM, Proctor & Gamble and others design for success*. San Francisco, CA: Jossey-Bass.

Guldemond, E. (2011). *Collaborative work environments in smart oil fields.* Doctoral dissertation. Nijmegen, The Netherlands: Radbout University Nijmegen.

Guldemond, E., ten Have, K., & Knoppe, R. (2010). *Organizational structures in collaborative work environments: The return of the matrix?* SPE paper 128274. Paper presented at Intelligent Energy Conference, Utrecht, Netherlands, 25-27 February 2010. Society of Petroleum Engineers.

Hepsø, V., & Gramvik, G. (2011). *What is a capability and a capability platform approach to integrated operations? An introduction to key concepts*. Working paper.

Julsrud, T. E. (2008). *Trust across distance. A network approach to the development, distribution, and maintenance of trust in distributed work groups.* Doctoral thesis, Norwegian University of Science and Technology.

Kaarstad, M., Rindahl, G., Torgersen, G., & Drøivoldsmo, A. (2009). *Interaction and interaction skills in an integrated operations setting*. Paper presented at The IEA (International Ergonomics Association) 17th World Congress on Ergonomics, Beijing, August 2009.

Lameda, R., & Van den Berg, F. (2009). *Integration is about people, SPE-123352.* Presented at the SPE Digital Energy Conference & Exhibition, Houston USA.

Lilleng, T., & Sagatun, S. I. (2010). *Integrated operations methodology and value proposition*. SPE paper no. 128576. Paper presented at Intelligent Energy Conference, Utrecht, Netherlands, 25-27 February 2010, Society of Petroleum Engineers.

Morgeson, F. P., DeRue, D. S., & Karam, E. P. (2010). Leadership in teams: A functional approach to understanding leadership structures and processes. *Journal of Management*, *36*, 5–39. doi:10.1177/0149206309347376

Næsje, P., Skarholt, K., Hepsø, V., & Bye, A. (2009). Empowering operations and maintenance: Safe operations with the "one directed team" organizational model at the Kristin asset. In Martorell, S., Guedes Soares, C., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications*. London, UK: Taylor and Francis Group.

Rindahl, G., Torgersen, G.-E., Kaarstad, M., Drøivoldsmo, A., & Broberg, H. (2009). *IO collaboration and interaction at Brage. Collecting the features of successful collaboration that training, practices and technology must support in future integrated operations.* IO Center report Program 4.1-003-. Trondheim, Norway: NTNU.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Journal*, *23*(3), 393–404. doi:10.5465/AMR.1998.926617

Salas, E., Rosen, M. A., Burke, C. S., & Goodwin, G. F. (2009). The wisdom of collectives in organizations: An update of the teamwork competencies. In Salas, E., Goodwin, G. F., & Burke, C. S. (Eds.), *Team effectiveness in complex organization. Cross-disciplinary perspectives and approaches*. New York, NY: Routledge.

Salas, E., Sims, D., & Burke, C. S. (2005). Is there a "big five" in teamwork? *Small Group Research*, *36*, 555–599. doi:10.1177/1046496405277134

Shuffler, M. L., Wiese, C. W., Salas, E., & Burke, C. S. (2010). Leading one another across time and space: Exploring shared leadership functions in virtual teams. *Revista de Psicologia y de las Organizaciones*, *26*, 3–17. doi:10.5093/tr2010v26n1a1

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. (2009). Integrated operations and leadership - How virtual cooperation influences leadership practice. In Martorell, S., Guedes Soares, C., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications*. London, UK: Taylor and Francis Group.

Skjerve, A. B., & Rindahl, G. (2010). Promoting trust between members of distributed teams. Lessons learned from an exploratory study in the petroleum industry. *Proceedings of 2010 IEEE International Conference on Systems Man and Cybernetics* (SMC), (pp. 1650-1658).

Thompson, G., & Li, J. Z. (2010). *Leadership. In search of effective influence strategies*. Oslo, Norway: Gyldendal Akademisk.

Walumbwa, F. O., Avolio, B. J., & Hartnell, C. (2010). Transformational leadership theories. In Levine, J., & Hogg, M. A. (Eds.), *Encyclopedia of group processes and intergroup relations*. Thousand Oaks, CA: Sage.

KEY TERMS AND DEFINITIONS

Integrated operation (IO): The integration of people, work processes and technology to make smarter decisions and better execution. It is enabled by the use of ubiquitous real time data, collaborative techniques and multiple expertise across disciplines, organizations and geographical locations. Put another way, IO is about linking people with the needed competence together at the same time, using information and communication technologies to support this.

Leadership: Intentional influence over others, through guiding, structuring and facilitating activities and relationships in a group or organization.

Self-Synchronization: The capability to empower those at the edge of an organization to operate autonomously.

Shared Leadership: Team members distributing leadership among them selves.

Team Adaptability: The ability of a team to change its performance processes in response to events and cues in its environment in a manner that contributes positively to the team's outcomes.

Team: Two or more individuals who adaptively and dynamically interact through specified roles as they work toward shared goals.

Teamwork: Collaborative processes performed by members of a team to reach their shared goal(s).

ENDNOTE

[1] Thanks to Grete Rindahl and Ann Britt Skjerve at the Institute for Energy Technology for compiling this list of IO teamwork characteristics.

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Chapter 8
Implementing iE:
Learnings from a Drilling Contractor

Martin Eike
Kongsberg Oil & Gas Technologies, Norway

ABSTRACT

On the Norwegian continental shelf, utilization of iE has been regarded as a vital measure for avoiding a rapid decline in production. Implementation has however proven to be challenging, and an unharvested potential still exist. Taking a capability approach to such implementation may help attain this remaining potential. Doing so requires a good understanding of what factors secure a successful and sustainable iE-implementation. Here, a case study of how a drilling contractor has adopted iE is used as basis for identifying such factors. An analytical framework rooted in the tradition of innovation theory is used for exploring the empirical material. The findings are further used as basis for presenting a set of recommendations that, if utilized, could help managers and change agents in their efforts of successfully implementing iE-capabilities within their organization.

INTRODUCTION

Despite many success stories, there is still a significant potential for harvesting additional value from intelligent energy (iE) within the oil and gas industry. As suggested by the editors of this book, utilizing a capability approach could help companies within the industry in this endeavour. Doing so does however require an understanding of what factors that enables a successful and sustainable implementation of such an approach, and how one can utilize these in a change management process.

This chapter aims to explore some of these factors. My starting point is the field of organizational innovation - more specific, theory describing how organizations build necessary capacity for carrying out successful innovation processes. I utilize this framework for a detailed review of how a major Norwegian drilling contractor has implemented the use of iE. The implementation was largely successful, and it proved decisive for the company to have a sufficient capacity for innovation as a basis for their efforts (Eike 2009). The learning's drawn from this can be used for enhancing our understanding of factors necessary for implement-

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ing sustainable iE-capabilities, both within- and in the intersection between different companies. By the end of this chapter my goal is to have shed light on some vital factors for conducting a successful and sustainable implementation of iE.

My ambition is not to present an exhaustive list of all factors that may have relevance, but to point to some, as identified in the empirical review, and describe how these could be utilized in the form of a set of recommendations to iE stakeholders.

I begin this chapter however by reviewing the "iE-history" on the Norwegian continental shelf, including a short introduction to the capability approach, which, in my opinion, emerged as a result of the difficulties many experienced when attempting to implement the concept. I then briefly review some critical points from the tradition of organizational innovation, before describing the "capacity for innovation"-framework. This is then put to use on the case study of how a drilling contractor has built the capacity necessary for introducing iE in its organization. Following this I return to the capability approach to iE-implementation and examine how my findings can help enhance our understanding of how to best aid the implementation of this. I end with suggesting areas relevant for further studies and some closing remarks.

iE IN NORWAY AND THE EMERGENCE OF THE CAPABILITY APPORACH

iE on the Norwegian Continental Shelf (NCS)

iE has had many names in Norway, but is best known under the term IO. When emerging in the early 2000s, two underlying factors were decisive for the extensive focus it was given:

Increased focus on operational efficiency. Both government and the industry grew increasingly concerned over the long-term ability of efficient petroleum recovery. If the recovery rate from existing reservoirs and discovery of new fields did not increase, and new technology was not utilized, the production rate would stagnate within 10-20 years (OLF 2003). These challenging outlooks, combined with a significantly lower oil price compared to today, pushed the industry towards searching for new measures for increased operational efficiency.

Fibre-optic cables on the continental shelf. A prerequisite for utilizing the opportunities of iE was the presence of a technological infrastructure on the continental shelf. The installation of fibre-optic cables in the North Sea began already in the early 1990s, but it wasn't until ten years later that an extensive grid was up and running (Paulsen 2005). This enabled the industry to move from short wave radio and satellite connections to real-time data sharing and video communication, necessary prerequisites for utilizing iE within offshore operations.

From this basis the industry moved quickly to implement iE. Between 2002 and 2005 a comprehensive amount of implementation efforts were initiated, both on industry and company level. Several iE-committees and a number of collaboration arenas were established along with comprehensive research programmes (NPD 2005, Wahlen et al. 2005). Ambitious goals were set for the future development of iE. A 2005 report developed by the Norwegian Oil Industry Association presented a two-generational timeline for future iE implementation. Generation 1, to be implemented between 2005 and 2010, involved real-time onshore-offshore communication and data sharing within individual companies, increased utilization of sensors, both down hole and on topside equipment, as well as more advanced modelling tools (OLF 2005). Generation 2, 2010-2015, would be a continuation of these efforts, but with several key modifications. Collaboration would move from being intra-organizational to inter-organizational. The operator's communication centres would function as hubs for several

different service providers and expert centres, each with their own collaboration rooms. This would enable increased real-time analysis and collaboration between all involved actors in the operation. The report also envisioned increased data input to onshore, operation centers manned 24 hours a day, and an increased amount of automated processing of data, leaving personnel to do more monitoring and less detailed decision making (ibid). Overall, this two-generational plan was ambitious, but was regarded as necessary in order to harvest the 250 billion NOK potential iE could entail (OLF 2003).

From 2005 and onwards a vide number of implementation efforts has been undertaken. The industry has moved towards the goals set out in 2005. However one has not managed to realize the full benefit potential of iE. Several factors are singled out as reasons for this:

- **Data Utilization:** Data is harvested, but not sufficiently systemized and utilized as basis for decision-making.
- **Sharing of Best Practices:** Lack of willingness to share knowledge and experiences across company boundaries, complicating the ability to cultivate best practices.
- **Contracts:** Lacking presence of contractual structures rewarding more efficient delivery of services, e.g. reduced number of drilling days per well.
- **Work Processes and Organizational Structures:** Tasks and work processes are not sufficiently altered, and organizational structures are kept mainly the same as before rather than designing new set-ups based on the new opportunities provided by iE.
- **HSE:** Absence of HSE-standards developed to accommodate for new working methods.
- **Competence:** The increased focus on utilizing new technology has not been sufficiently backed up by employing personnel with relevant IT-competence, nor training of current personnel in the use of new tools (OLF 2007, OG21 2008, Raasen 2008).

Faced with such a wide range of challenges, the focus within iE in Norway has shifted. In the first part of the 2000s, the industry's focus was mainly on utilization of new technology – setting up onshore-offshore connectivity, collaboration rooms, software solutions etc. The wide range of challenges that arose as the implementation continued in to the final half of the 2000s changed this focus. It became evident that a more fundamental approach to iE-implementation was needed; encompassing all technological and organizational components involved in such a major change effort. I regard this realization as the starting point for the emergence of what can be described as the capability approach to iE-implementation.

The Capability Approach

Taking a capability approach to iE means acknowledging that there is an interdependency between technology, people, process and organization. It is the ability to design and implement iE-efforts that are made up of the appropriate mix of these factors, rather than exclusively focusing on one, i.e. technology, that generates long-term value. Done correctly it will provide the organization with a problem solving architecture (Schreyogg & Kliesh-Eberl 2007). Henderson and Kulatilaka define capability delivery as "the combined capacity and ability to plan and execute in accordance with business objectives through a designed combination of human skills, work processes, organizational change and technology". (Henderson and Kulatilaka, in Edwards, et al. 2010:5). This definition highlights both the equal importance of technology, people, process and organization, as well as the link between the utilization of elements made up of these and the company's overall business goals. Both are characteristics of the iE-focus that has emerged on the NCS

after 2005, and can be seen as a more mature approach to utilizing the concept. Not only is there an increased understanding of the necessity of complementing the technology dimension with other elements, but also the need for connecting iE with overall business objectives and performance output. Managers and other stakeholders must see a return on investment.

Building a sustainable iE capability platform involves designing, implementing and continuously managing the initiative within the organization. This process can be viewed as very similar to that of discovering, developing, and implementing a new product or process, i.e. a process of innovation. Examining what characterizes the ability to have a sufficient capacity for conducting an innovation processes, as will be done in this chapter, could then enable us to better understand the requirements for implementing and sustaining an iE capability platform.

CAPACITY FOR INNOVATION WITHIN A NORWEGIAN DRILLING CONTRACTOR

I will examine this through utilizing the field of organizational innovation. I will look at the implementation of iE within a major Norwegian drilling contractor as an innovation process, review how the company has built a sufficient capacity for this innovation, and also what the features of this capacity are.

Capacity for Innovation

The Process of Organizational Innovation

I begin with three short, but vital, points regarding organizational innovation as used in this chapter:

First, to understand innovation as a theoretical concept it is important to distinguish it from an invention. The latter involves creating something new, whether it is new product or a new idea, while the former describes the process of adopting this invention. Innovation is in other words not synonymous to the act of inventing something, but is the process of developing and implementing the invention.

Furthermore my focus here is primarily intra-organizational innovation. I regard innovation as being "the first use of an idea within an organization (…), whether or not the idea has been adopted by other organizations already" (Nord & Tucker 1987:6). The fact that the drilling contractor to be reviewed below wasn't the first company on the NCS to adopt iE is of less relevance. When it first emerged within the company, it was regarded as something new, and thus an intra-organizational innovation process was undertaken.

Finally, I view innovation as a phased process, consisting of a design and an implementation phase. The former covers the process from a new product or idea is discovered and first enters the organization, is put on the agenda, further developed, and until a formal decision to implement is made. The latter describes the actual implementation.

Capacity for Innovation

An organizations ability to successfully carry out such a process is dependent on its ability to build a sufficient capacity for innovation. I define capacity for innovation as an organizations ability to discover, develop and adopt new products or ideas. This can be difficult because it involves the organization having to prioritize non-routine activities rather than routine activities. It has to go beyond daily routines and facilitate for activities not previously conducted (Simon & March 1958). In this chapter, I will focus on three areas in which focused efforts are vital for building capacity for innovation: individual employees, characteristics of how the organization is structured, and how it interacts with its environment.

Individuals

Individuals can influence organizations ability for non-programmed activity through internal agenda-setting, pushing for a formal management decision to implement, and through working as change agents to support this implementation. Three individual roles are common in an innovation process, the investor, the entrepreneur, and the broker (Simon & March 1958). The investor has the authority to decide how the organization should prioritize its resources, the entrepreneur brings in and develops new ideas, while the broker brings these two together so that an entrepreneurs ideas gain access to the resources necessary for actual implementation. Whether the broker function is in use, or even exist, depends on the extent to which the organization has other channels of communication between investors and entrepreneurs. If so, the broker-role is of less relevance.

The role with particular importance for building a capacity for innovation is that of the entrepreneur. An individual's ability to harvest and/or develop new concept and ideas can constitute a vital part of an organizations non-programmed activity. When the innovation processes' starting point are ideas harvested externally, the entrepreneur functions as a translator, bringing home new concepts and adapting them to the local institutional conditions (Røvik 2007). Both then, as well as when the idea originates within the organization, the entrepreneur take on the role of an innovation champion, functioning as "a individual who throws his or hers weight behind an innovation, thus overcoming indifference or resistance that the new idea may provoke in an organization" (Rogers 2003:414). The innovation champion does not necessarily have much formal power or a management position. Rather, subject matter knowledge, often combined with good communication skills, is more important.

Summarized, the innovation literature enables us to conclude that:

- One or more individuals working actively in the role as champions increase an organizations' capacity for innovation.

How the Organization is Structured

Organizations are made up of both permanent and temporary building blocks. How these are structured influence the capacity for innovation.

When dealing with permanent ways of organizing, the innovation literature has given much attention to the dichotomy of mechanistic versus organic structures, and to what extent these promote innovation (Burns & Stalker 1961). It is common to look at the relationship between these and the effect they have in different parts of the innovation process through applying an ambidextrous approach (Duncan 1976). The "ambidextrous model" concludes that organic structures promotes an innovation processes in its design phase, while mechanistic structures promotes it in its implementation phase. This is because the less formalized and centralized conditions of organic structures provide better conditions for innovation and creativity, which is important in the design phase, while the hierarchical and structured conditions found in the mechanistic structure makes it easier to achieve a rapid and effective implementation in the latter phase (Zaltman et al. 1973).

Temporary structures arise in the shape of what we can describe as project organizations. These are provisional organizational units created to solve one, or a specific number of tasks (Nylehn 2002). Personnel from different parts of the organization are gathered in such a unit for the duration of the project, before returning to their regular positions. The projects duration, how extensive the project organization is, and how many- and complex its tasks are, can vary. On the one hand it can be a matter of a few uncomplicated tasks solved over a short period of time with only a few people involved. Planning the company's Christmas party can be an example

of this. On the other hand, projects can involve a large number of comprehensive tasks, requiring a large number of dedicated personnel for a long period of time. Design- and construction of a new rig is an example of such a project. Studies show that the use of a temporary structure in the shape of a project organization consisting of relevant personnel from the parent organization, change management consultants, and end users (if applicable) when conducting a change process significantly increase its potential for success (Lien & Fremstad 1989). Setting up and actively using a project organization will then function as a capacity enhancing factor for an ongoing innovation process. The more resources put in to the project organization, the higher capacity for non-programmed activity.

From reviewing both permanent and temporary conditions of how an organization is structured, we can deduce the following conclusions. First, for permanent structures it's evident that:

- An organization capable of operating with different structural conditions in the two phases of the innovation process (organic structure in the design phase, mechanistic structure in the implementation phase) will increase its capacity for innovation.

Second, for temporary structures we can conclude that:

- An organization utilizing a project organization when conducting change processes will enhance its capacity for innovation and thus increase its potential for a successful implementation.

Environment

The surrounding environment can affect an organizations capacity for innovation in two ways. First, the environment can have an inspiring effect on the organization. Ideas and practices popular in its surroundings may have a higher chance of getting on the agenda internally, and thus a greater possibility of being implemented. Secondly, relations to- and collaboration with other organizations can aid the process through collaborating on the building- and use of non-programmed abilities.

The first role is best addressed by utilizing what the innovation literature describes as a system perspective. A system consists of a number of organizations acting within a set of institutional preconditions such as norms, rules and expectations (Edquist 2005). The drilling contractor described in this chapter can be regarded as part of the system called "the Norwegian petroleum sector". Within such a system a consensus concerning what is the correct way of organizing ones company may emerge. Such *organizational recipes* might emerge within a certain time period and then be regarded by the member organizations within the system as "the correct, most appropriate, most effective, modern, and even as the most natural manner of organizing" (Røvik 1998:13). If such expectations are formed within the system an organization is part of, they can act as a motivator, alternatively as an enforcing factor, for building a capacity for non-programmed activity extensive enough to ensure a successful implementation of the organizational recipe in question.

The second role of the environment can be described by adopting a network perspective. The focus here is how organizations work together to develop and implement new products and ideas, often through formal partnerships. "Inter-organizational networks are a means by which organizations can pool or exchange resources, and jointly develop new ideas and skills" (Powell & Grodal 2005:59). "Clusters" of companies working together to ensure innovation, often in close collaboration with R&D-institutions and governmental bodies, is seen as vital for ensuring a successful innovation process (Porter 1990, Asheim & Gertler 2005). How close these organizations work together varies from formalized collaboration through contracts and other binding

documents, to more informal and irregular ties. The innovation literature has given most attention to the former, revealing "a strong positive relationship between alliance formation and innovation" (Powell og Grodal 2005:65).

Based on this we can draw two conclusions:

- An organization is motivated to increase its capacity for innovation if a trend in the system it is part of leads it towards adopting new ideas or ways of working.
- An organization increases its capacity for innovation through collaborating closely with other entities within its network.

In summary, we find that the innovation literature gives us indications regarding what factors make up an organizations capacity for innovation. To back up these assumptions however we need to test the framework on an actual iE-process. This will help us ensure its viability, and can then further aid us in our goal of identifying what factors that make up a capability for iE-implementation and how these can be utilized?

A Norwegian Drilling Contractor

The iE-process reviewed in this chapter has been conducted within a major Norwegian drilling contractor. Common for many descriptions of iE-implementation are their focus on such processes within operator companies. This is only natural since these are the biggest actors within the E&P-industry and many of them has put much effort in to increasing their level of iE-utilization. However, the increased focus on inter-organizational collaboration in relation to iE-implementation increases the importance of also understanding such processes within organizations serving the operator, such as drilling contractors. Examining iE within a drilling contractor will not only provide us with better understanding of such processes within this specific type of organization, but will also provide us with knowledge transferable to other company types.

The drilling contractor described here is among the biggest on the Norwegian continental shelf, in addition to having a comprehensive amount of international operations. It has over 3000 employees and its history dates back to the early 1970s. The following three divisions have been examined in the study used as empirical basis in this chapter:

- **Platform Drilling:** Provides platform drilling services to several operators on the Norwegian and UK continental shelf.
- **Mobile Offshore Units:** Owns and operates mobile offshore units, conducting operations worldwide.
- **Technology:** Provides D&W-related engineering services, from specific tasks related to ongoing drilling operations, to complete EPCI-projects.

The review of the iE process within this company was carried out as a qualitative case study in 2009. A comprehensive data material was collected to form the empirical basis for the study. This was mainly done through:

- Conducting 11 semi-structured interviews with key personnel in the organization. To understand the process from as many relevant viewpoints as possible, the list of interviewees included top- and middle-management, champions and other change agents, as well as a number of operational employees whose everyday work had changed.
- Gathering and analysing a comprehensive document material containing information relevant for the process. These include strategy documents, meeting and workshop memos, implementation plans, project plans and reports, as well as both internal and external news articles and other press and marketing material (Eike 2009).

It proved essential to combine these two data harvesting methods as it allowed for cross-validation of information, as well as providing supplementary input on a number of areas where either none-, or only a few of the informants had first-hand knowledge of the facts, or where the change efforts were poorly documented in the written material. Combined, the information from both interviews and documents provided a sufficient basis for understanding and analysing the iE-efforts undertaken.

The process is described from its early beginning in 2003 until the end of the decade. I divide the process in to two phases, design and implementation. The first covers the company's iE-history from the concept entered the organization, was put on the internal agenda and further developed, and until a formal decision to implement was taken. The latter phase describes the actual implementation. As noted by many in the innovation literature, such a process rarely follows a strict theoretical classification in two phases. Rather the process will be exposed to a series of "feedbacks" and "loops" leading to a potential shift between these phases throughout the process (Kline & Rosenberg 1986). This has also been the case within the company described her. iE was partly implemented in day-to-day operations prior to a formal decision to implement was taken by executive management. However, as is also underlined by contributors in the innovation literature, I believe using a phased framework will enable us to understand the process in a god manner. When describing the design phase I will cover the company as a whole, while examining each division separately when describing the implementation phase.

The Design Phase

The initial steps towards iE was taken by a small group of individuals in 2003 who independently of each other became interested in, and wished to develop, the concept within the company. One of these was an engineer who visited a R&D-event hosted by a major operator on the Norwegian continental shelf, presenting how technological solutions and experiences from NASA could be utilized within the oil industry. He held an internal presentation on the subject afterwards, championing the ideas. Simultaneously two other employees were working on digitalizing the daily drilling reports used within the company's ongoing operations. This would later be further developed in to a software solution for monitoring and supporting drilling operations from onshore operations centres. All three of them worked in, the then, recently established technology division. The divisions' main goal was to capitalize on the company's technology and engineering competence beyond utilizing these only as a support function towards drilling operations. It was brought to the marked as a separate set of services, not necessarily bundled with standard drilling operations. For the newly established divisions' management team it was important to appear as an independent entity towards the marked, with high focus on being innovative and utilizing new technology. The then president of the technology division highlighted this in his interview, stating that he was a strong believer in using technology as an enabler to work smarter, and that securing long term survival demanded being in the forefront of this development.

These early initiatives were not coordinated, and were not part of a single strategy or program within the company. The ideas existing in the organization at this time had different origins and characteristics. The input originating from NASA focused on planning and design of engineering projects, while the initiative to digitalize the daily drilling report focused on day-to-day operations. In other words, some differences regarding what iE were, and could become, existed.

Around a year after these early initiatives, it became evident for the company that a further development of iE would be dependent on collaboration with key customers. The reason

behind this was twofold: First, it was essential that customers came in and covered part of the costs involved in setting up the infrastructure needed for iE. Secondly, a clear desire from key customers to collaborate on implementing iE-efforts would function as an internal motivator for the drilling contractor, underlining that such solutions were in demand by the marked. In 2004 a formal collaboration with a key customer materialized, giving the iE-process a critical boost. The customer, a major operator regarded as one of the early adopters of iE on the Norwegian continental shelf, approached the company, asking for solutions that would enable closer collaboration around daily drilling operations. As a response, the company established a project group tasked with identifying and implementing specific efforts to comply with this. Four drilling operations were conducted for the operator at the time, and increased collaboration between these, as well as with the operator, were implemented. Up until now, function specific support personnel onshore had been situated at different locations. Now the company gathered these in the same office landscape, meaning that QHSE, operational support, maintenance and logistics services were bundled for all four operations. In connection to this, the company's first videoconference facilities were installed, enabling meetings with both operator and platforms. A liaison position was also established, further enhancing collaboration with the operator. This position was permanently stationed in the operators onshore operations centre. Overall, the changes implemented went beyond what the customer had requested. The opportunity given by the customer approaching the drilling contractor and asking for increased collaboration was used to accelerate the internal iE-process.

The following year, a second customer, also a major operator, played an important part in furthering the iE-process in the wake of publishing an invitation to tender for drilling operations on several installations. As part of the drilling contractor's response to this was a dedicated appendix highlighting iE-solutions as a distinct service that could be provided as part of the overall platform drilling services. The potential cost reduction for the customer was described as comprehensive. In the end, they were handed the contract. Many pointed to the inclusion of a separate "iE-appendix" as vital for this.

With iE-solutions now implemented on operations towards one customer, and promises given to another, the drilling contractors executive management realized that an overall strategy on iE was needed. Based on this realization, a project organization tasked with developing a detailed strategy for future use was established in 2005. The mandate given to the group stated that it should "establish processes and implement required changes to capitalize on the opportunities created by onshore support centers and related IT tools". The main project group consisted of two of the three individuals who had been part of setting iE on the agenda two years earlier, as well as representatives from operations, maintenance, QHSE, logistics, IT, and an employee representative. A steering committee with members from the company's management group was also made part of the project organization. The group developed a general strategy highlighting four areas as being the main goals for further iE-implementation. These were to increase drilling efficiency, reduce number of administrative tasks conducted offshore, reduce travels – both onshore-offshore as well as between different office locations, and finally to establish a dedicated unit tasked with offering iE-implementation services to the marked through change management consulting. The executive management team formally approved this strategy the same year. The reason behind establishing the project group, as well as the management teams formal decision to implement iE was twofold: Firstly, iE was regarded as a vital tool for improving internal efficiency. Reducing administrative positions offshore, reducing travels, and capitalizing on providing iE-based consultancy services were

all regarded as efforts with a potential positive impact on the company's earnings. Secondly, the management team felt having a clear strategy on iE would send an important signal to the marked, enabling the company to stand out compared to other competitors.

With a formal decision taken to utilize the opportunities provided by iE, the company now turned to conducting a full scale implementation.

The Implementation Phase

When reviewing this phase, it is useful to separate between two levels of iE-implementation within the company. Firstly general efforts implemented equally across all three divisions, and secondly, implementation efforts specific to the three divisions. As will become evident below, the degree- and type of implementation varies some when comparing platform drilling, mobile units, and the technology division.

General Implementation Efforts

Four iE-measures were regarded as having a potential for improving ways of working within all division, and were therefore equally implemented within all of these.

- **Videoconference Facilities:** Was regarded as crucial in order to reduce travels, both onshore-offshore and between locations. The first videoconference facilities were built already in 2004 as part of changes made in relation to the platform drilling services conducted for a major customer. After this however the videoconference capacity was significantly increased, from four to 60 rooms in the period between 2004 and 2009. Integrated videoconference facilities were part of two major building upgrades at two of the office locations in Norway. The actual use of these facilities also grew within the same time period. Comparing 2007 with 2008 showed a 324 percent increase in the number of logged hours in the system.
- **Personal Collaboration Software**: Implemented in 2005, enabling real-time chatting, video-conferencing, and document sharing from individual PCs. This was installed on all computers within the company, enabling all employees to utilize the tool. A survey conducted in 2007 showed that 90 percent of those asked were logged on daily, while 91 percent said they used the software to communicate with fellow employees.
- **Rig Visualization Tool**: A software tool with exact drawings and pictures of the rigs the company operated on. The tool was regarded as useful for planning of operations for all divisions. The implementation of this was only partly successful. While in full use towards some operations, other chose not to make it a part of their actual routines (despite it being included in formal work processes). This were in large part due to some initial incidents where the drawings and pictures proved not to be consistent with actual conditions offshore, leading to last minute changes having to be made. While never causing any critical problems, it made some employees sceptical to actively utilizing it as a tool.
- **Open Office Landscape**s: Based on the philosophy that open landscapes created a better arena for collaboration, several floors on different office locations were changed to accommodate for this. Open landscapes were also used as standard interior when upgrading and expanding offices buildings.

A converging observation regarding these four efforts is that not all employees necessarily regarded them as being part of an overall iE-effort. This is interesting because it reveals a difference

in understanding of what the iE-concept entails. Some regard all of these elements as being parts of iE, while others see them as separate implementations of technology and ways of working not necessarily describing them as iE-efforts. The latter group underlined that IO first and foremost was a tool for onshore-offshore collaboration and support, and that these efforts were technologies used by a number of companies, both within oil & gas as well as other industries, without being included in an overall framework such as iE.

Platform Drilling

The iE-implementation had already been initiated in this division towards one major customer prior to the formal management decision to implement iE within the company. Further implementation was conducted towards this operator, as well the operator with whom a new contract was agreed upon in 2005.

For the former, additional work was conducted in 2008 to further improve the iE set up. The majority of the onshore support organization was moved in to an onshore support centre where all platforms were simultaneously monitored. This provided the opportunity for additional cross-operational collaboration, as well as sharing of onshore resources. An additional position, that of operations planner, were also moved onshore to further reduce administrative work on the platform. Finally, two additional positions were established onshore, efficiency engineer and senior maintenance engineer. These were placed in the operations room and tasked with ensuring efficient coordination and experience transfer across the different operations.

The iE-implementation in drilling operations conducted for the latter operator developed in a somewhat different direction. Shortly after signing the new contract, a formalized technology partnership was also established between the two companies. The operator wanted the drilling contractor to take on the role as subject matter expert within the field of drilling in relation to innovation and new technology. The operator highlighted the focus on iE as an integral reason for choosing the company. It was decided to conduct the initial iE-implementation as part of this partnership. A project group with representatives from both organizations were established. As a result of their work it was decided to initiate an iE pilot on one installation. This was done in 2007. An onshore support centre was established where two dedicated employees were brought in to function as operational advisors together with one planning engineer. All had extensive experience from offshore work on the platform. They were tasked with monitoring and supporting the operations, ensuring efficiency, and transfer of best practices between shifts and crews. The support centre was equipped with videoconference abilities and software for managing and continuously monitoring the ongoing drilling operations. After being in use for almost a year, with good operational results, the operator requested the same service for two additional platforms. A project group tasked with ensuring this implementation was established early 2008, and identical set ups for these two operations were implemented in May that year. Overall, this meant that the drilling contractor now used onshore support centres for three out of six operations conducted for the operator on fixed platforms.

Two factors appear to have been of particular significance in relation to iE-implementation in the platform drilling division. First, close to all of the employees working in the onshore support centres had considerable experience from the respective installations, knowing both the crews and facilities. This enabled them to collaborate closely with drilling supervisor, toolpusher and others offshore from the beginning, easing potential start-up difficulties this change could potentially entail. Second, a dedicated position as IO-Manager was created within the division, tasked with aiding implementation and follow up of all iE-initiatives,

reporting directly to the company's COO. Later, this positions responsibility was also extended to the Mobile Offshore Units division.

Mobile Offshore Units

The iE-implementation here was conducted much later compared to the former division, and operational iE-solutions of significant scale were not operational until 2009. This was partly due to the high profitability of these operations, with rig-rates being solid throughout the decade, decreasing the need for cost reducing and efficiency increasing measures. Also, the technological challenges in relation to full iE-utilization were more extensive, involving the need for a more demanding communications infrastructure on the rigs. In 2008 however management felt the division had potential for increasing its efficiency and cross-operational collaboration. A project organization was set up to investigate potential benefits of an iE-based improvement process, as well as creating an implementation plan for this. In 2009 this plan was put in to action. It involved gathering all support personnel for these units at the same geographical location, and in the same office building. Onshore support centres for all rigs, with video communication and software for managing and monitoring the operations were set up and personnel with operational support functions were placed here. Personnel with secondary support functions were placed together in close proximity to these rooms. This allowed for increased cross-collaboration between the different units. Necessary infrastructure on the rigs themselves was also installed, ensuring the ability to conduct continuous transfer of video and data.

Technology Division

Since this division mainly supplies engineering services, the potential for operational iE-utilization beyond the general measures implemented in the organization was smaller compared to Platform Drilling and Mobile Offshore Units. The general iE-efforts have been put to good use, and it appears as if the potential for utilization has been met.

One sub-department within the Technology-division did however further the iE process in a new direction. One of the companies main goals agreed upon in 2005 was to establish a dedicated unit tasked with offering an iE-based change management consulting service to the marked. This was formally made a sub-department in Technology in 2007. It approached potential customers independently of the company in general, building an own portfolio of customers. It did however also provide in house support in connection to several of the iE-implementation efforts, playing a vital role in these.

Capacity for Innovation Applied to the iE-Process

Returning now to the capacity for innovation framework and those areas in which focused efforts are vital for building an organizations capacity for innovation: individual employees, characteristics of how the organization is structured, and how it interacts with its environment, it is evident that factors within all of these have been vital for the drilling contractors ability to ensure a comprehensive iE-implementation.

Individuals

From the literature review above we concluded that: One or more individuals working actively in the role as champions increase an organizations' capacity for innovation.

Individuals were particularly important in the design phase, where several employees took on the role as champions and early developers of what would later be a broader iE-process within the company. Also, management in the Technology division can be seen as investors, allowing for this early work to be conducted within their organization.

In the implementation phase champions also played a vital role. Here however the role was formalized, both by using in-house consultants from the iE-unit in the Technology division, but perhaps most importantly, through creating a full time position as champion in the form of an IO Manager.

How the Organization is Structured

First, the literature review concluded that: An organization capable of operating with different structural conditions in the two phases of the innovation process (organic structure in the design phase, mechanistic structure in the implementation phase) will increase its capacity for innovation.

Based on this it is interesting to note that much of the early iE-work were conducted in the then recently established Technology division. The qualitative data material gathered for the study described here does not provide basis for concluding that there is a comprehensive difference in how this is structured compared to the other three divisions. However, it appears as highly likely that this had a more organic structure compared to the other divisions, who were more focused on day-to-day operations and thus more likely to have a more mechanistic structure. In general it is safe to say that drilling and well operations are characterized by a large degree of hierarchy and a fixed task allocation between different sub-units and employees. In view of this, having a more open structure in the Technology division might have been vital in helping the company bring in and develop the iE-concept in the design phase, while the fixed structural conditions may have aided implementation in the Platform Drilling- and Mobile Offshore Units divisions.

Second, the literary review concluded that: An organization utilizing a project organization when conducting change processes will enhance its capacity for innovation and thus increase its potential for a successful implementation.

It's evident that this has been a much-used tool when both developing and implementing iE within the company. An extensive project organization with members from most units and position levels were vital in developing an iE-strategy in the design phase. Further, setting up project organizations and allowing personnel to prioritize tasks related to iE-implementation in addition to their daily responsibilities, were much used in relation to the different change processes carried out as part of the implementation. Mostly made up by internal members, it is also interesting to note that an inter-organizational project organization were set up jointly with a major customer, enabling the development of a custom-made set up.

Environment

The first conclusion from the literary review in regards to the environments influence was that: an organization is motivated to increase its capacity for innovation if a trend in the system it is part of leads it towards adopting new ideas or ways of working.

It's clear that such a trend existed within the Norwegian oil industry, and that this was an important reason behind the decision to implement iE within the company, since the management team felt it would give them a potential advantage in the market compared to their competitors. The considerable focus on iE in the industry was also the main driver behind establishing an independent consultancy unit targeting what was regarded as an emerging market.

The second conclusion stated that: An organization increases its capacity for innovation through collaborating closely with other entities within its network.

Collaboration with other organizations, in this case major customers, were a vital part of implementing iE, especially within the platform drilling division. As part of the earliest implementation efforts in this division, the customer were more of a motivator, encouraging the company to increase

its focus on iE. Later, when working with the second company - with whom one had a formalized technology partnership, the collaboration were more formalized, and joint project groups were established. This ensured increased access to relevant knowledge and experience, as well as an increased ability to understand the customers' requirements.

Capacity for Innovation, Summarized

In summary, the company managed to build a capacity for development- and implementation of iE through utilizing a series of relevant measures. They managed to go beyond daily routines, taking the time to- and ensuring sufficient allocation of resources for completing a close to full iE-implementation.

Building on this, we now return to the capability approach and how factors enhancing implementation in the case examined here could be utilized when building an iE capability platform.

IMPLEMENTING iE

As described above, taking a capability approach to iE means to utilize the combined efforts of technology, people, process and organization to enhance performance in accordance with the organizations business objectives.

The main goal of this chapter is to identify some factors that could be relevant for securing a successful and sustainable implementation of such a set of capabilities.

Having examined the capacity for innovation framework and how this has been utilized by a Norwegian drilling contractor, we are left with several learning's which I regards as having transferability to the capability approach. The following is a set of recommendations that can, if utilized, help organizations within the E&P-industry when rolling out an iE capability platform.

Formalize the champion role. Having a dedicated champion, or several champions, working towards the operational environment will ensure a close and continuous focus on change management. Such a role may be filled by external consultants, working for the company on a medium- or long term contract, or through employing personnel in full time positions. Vital for their ability to be successful in such a role is a clear mandate given by top management, and a clear line of communication to this group. This allows for the change management efforts to be aligned with the company's overall strategy, and for potential delays and resistance to be met more effectively through the ability for management to back up these efforts within the line organization.

Build a project organization. Setting up a project organization alongside the regular structure can aid implementation in several ways. First, it enables bringing personnel out of their daily roles and utilizing their competence and assessment abilities for improving the change efforts quality. Second, it functions as a collaboration arena for those responsible for the implementation effort – the change agents, those affected by the change, and management responsible for the target organization. Personnel from the parent organization can be made part of the temporary project organization part- or full time for a fixed period while the implementation efforts are ongoing. Third, one can build on the philosophy behind such a temporary project organization – to aid a distinct implementation effort, but instead make it a formalized part of the organizational structure. Much like formalizing the champion role above in a full time internal position, such a group will be tasked with continuously following up all relevant implementation efforts in the company. Doing so can be especially useful in big and complex organizations, i.e. major operator companies, where a large number of implementation efforts are ongoing at any given time. The need for someone to coordinate these and to ensure that all of them are

based in the same overall philosophy falls within the realms of this group. Some major operators have such entities today.

Create arenas for innovation. As evident from the case described in this chapter, it can be vital for an organizations ability to both bring in and develop new ideas that there are internal areas with a more organic and less formalized structure. This can help spur innovative thinking around how one can improve execution of day-to-day activities. Facilitating innovative behaviour can be done through allowing individual employees to use some of their working time to come up with-, and discuss different approaches to how they execute their jobs. On an individual level, this can be done through setting aside a specific number of hours for each individual to conduct such activities, or through gathering personnel for a few hours or a day regularly to collaborate on new ideas. This will provide individuals having first-hand knowledge of existing challenges within the company's daily workings with an arena for finding solutions to these challenges.

Establishing a permanent organizational unit, as described in the point above, can also function as an important arena for increased innovative activity. When the unit is permanent, it will have increased room for carrying out activities beyond just overseeing implementation. Conducting R&D activities within the area of iE, developing new approaches and exercising thought leadership within the industry fits naturally in to the scope of work for such an entity.

Utilize rigid structures. A high degree of hierarchy and task specialization is indicative for operational units within the E&P industry. Such conditions are often viewed as a challenge when implementing changes. However, if utilized correctly, these conditions can be an advantage. Such units are used to quick and effective execution of work tasks based on a specified scope of work. Information moves fast between different organizational levels, and one is used to focusing all necessary efforts on getting things done. For a new initiative to succeed in this environment it must be packaged correctly. The rationale behind why the change is implemented must be clearly communicated to those affected, highlighting why it is necessary and how it will be beneficial to personnel working in the targeted units. Management backing is important, but more vital is visible support from "opinion leaders" within the organization. These do not necessarily hold management positions, but are individuals highly regarded by their peers. Typical characteristics of such individuals are a high work ethic, lengthy experience, and extensive knowledge of their professional field. Getting them onboard might be difficult, but could prove vital to ensure overall buy-in - nothing is as persuasive as a convinced skeptic. A vital part of the onshore support centers success in the platform drilling division described above was the fact that personnel working there had lengthy experience from the installations they were serving. They knew the facilities, and they knew most of the crew. When the support center first came online the operators drilling supervisor, the toolpusher and others on the installation knew they were talking to someone who had first-hand knowledge of the conditions offshore, making it easier to quickly build trust between the two. Instead of being viewed as challenging the existing structure, the onshore support center was regarded as a positive addition to this. If the change effort is designed with such considerations in mind, one will be better able to utilize the positive characteristics of a typical operational structure.

Collaborate with other organizations. Cross-organizational collaboration – bringing together companies in different parts of the E&P value chain, is often highlighted as a high-potential area within iE. A key success factor is to include relevant external organizations (services providers, customers etc.) to participate in the actual design

of new initiatives, not only to be part of an already fixed program or solution. Bringing in people from "the other side" of the company's boundary at an early stage will bring perspectives not easily accessed otherwise. A service company may provide input to how they best can provide their services within an iE-model, and customers, as described in the case above, can communicate the specific requirements they expect their provider to follow. Including such input as early as possible in a change effort will increase its chances for being successfully implemented. Working together with other relevant companies will also increase the access to relevant knowledge and experience, as well as actual resources to conduct the work necessary for developing and implementing a new initiative.

Follow trends in the environment sensibly. iE has become a trend in the industry, viewed by many as a required measure if one is to secure operational efficiency. This notion has been backed up by a growing literature, conferences, articles, and comprehensive programs within most of the major companies in the industry. When iE receives such high-focus on an industry level, it is easy for single companies, and those managing these, to get caught up in the hype. However, the rationale behind iE should always be actual benefit realization, whether this is cost reduction, reducing time used on specific operations, or POB reduction, and not to imitate what appears to be a dominant trend within the industry. As the manager of an organization implementing iE-efforts, one should always ensure that change agents and efficiency programs are followed by a set of KPIs closely measuring the effect of their initiatives. Ensuring actual implementation is not only important for improving the organization internally, easily identifiable success stories are also the strongest possible signal one can send to the marked, stating that this is a prioritized effort which one has the competence and knowledge for utilizing successfully.

FUTURE RESEARCH DIRECTIONS

It is my opinion that the emergence of a capability approach within the field of iE comes as a result of the difficulties many companies has experienced when conducting implementation efforts, and the subsequent realization that a more holistic approach is needed. Since iE will continue to be a high-focus area for the years to come, so will utilizing a capability approach to running iE change initiatives. It is therefore vital to increase our understanding of how such initiatives are best implemented. Such knowledge should be harvested from real-life cases where implementers have experienced both successes and failures. It is important that success factors are identified based on actual implementation efforts and not just theoretical assumptions and programs that have been designed but not put to use within an organization. Building a larger literature could help increase the number of successful implementations in the years to come.

CONCLUSION

In many mature petroleum regions, including the Norwegian continental shelf, extracting resources is becoming more technologically challenging and more cost intensive. Measures helping us increase recovery while reducing costs are necessary for long term sustainability. iE is one such measure.

For fields working on a close-to-break-even margin, an efficient utilization of iE could make up an essential contribution to ensuring production beyond expected lifetime. This does however require one to have the ability to conduct a successful and sustainable implementation process. Utilizing the recommendations presented in this chapter, together with additional implementation measures that may be identified as a result of future empirical studies, could provide change agents with an increased ability to succeed in this endeavour.

REFERENCES

Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: Regional innovation systems. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

Burns, T., & Stalker, G. M. (1961). *The management of innovation*. London, UK: Tavistock Publications.

Conference and Exhibition, Utrecht, The Netherlands, March 23-25 2010.

DiMaggio, P. J., & Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, *48*, 147–160. doi:10.2307/2095101

Duncan, R. B. (1976). The ambidextrous organization. Designing dual structures for innovation. In Kilmann, R. H., Pondy, L. R., & Slevin, D. P. (Eds.), *The management of organization: Strategy and implementation*. New York, NY: North Holland.

Edquist, C. (2005). Systems of innovation: Perspectives and challenges. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

Edwards, T., Mydland, Ø., & Henriquez, A. (2010). *The art of intelligent energy (iE)- Insights and lessons learned from the application of iE*. SPE 128669, Paper presented at the SPE Intelligent

Eike, M. (2009). *Capacity for innovation – The implementation of integrated operations within a Norwegian drilling contractor*. University of Bergen.

Klein, S. J., & Rosenberg, N. (1986). An overview of innovation. In Landau, R., & Rosenberg, N. (Eds.), *The positive sum strategy. Harnessing technology for economic growth*. Washington, DC: National Academy Press.

Lien, S., & Fremstad, J. K. (1989). Organisering av Organisasjonsendring. In Egeberg, M. (Ed.), *Institusjonspolitikk og Forvaltningsutvikling*. Oslo, Norway: Tano.

March, J., & Olsen, J. P. (1989). *Rediscovering institutions. The organizational basis of politics*. New York, NY: Free Press.

Nord, W. R., & Tucker, S. (1987). *Implementing routine and radical innovations*. Lexington, KY: Lexington Books.

Norwegian Oil Industry Association, OLF. (2003). *E-drift på norsk sokkel – det tredje effektiviseringsspranget.*

Norwegian Oil Industry Association, OLF. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf.*

Norwegian Oil Industry Association, OLF. (2007). *Integrerte Operasjoner – Akselerert utvikling på norsk sokkel*.

Norwegian Petroleum Directorate (NPD). (2005). *Styringsgruppen for edrift.* Retrieved from http://www.npd.no/Norsk/Emner/IO/Styringsgruppen+for+Edriftforum/ edriftforum_styringsgruppe_mandat.htm

Nylehn, B. (2002). *Prosjektorganisering. Teorigrunnlag og implikasjoner*. Bergen, Norway: Fagbokforlaget.

OG21 – Nasjonal Teknologistrategi. (2008). *Technology strategy for integrated operations and real time reservoir management.*

Paulsen, G. (2005). *Informasjon over Nordsjøen: Telekommunikasjon på norsk sokkel.* Forskningsrapport 3/2005. Handelshøyskolen BI. Institutt for innovasjon og økonomisk organisering. Senter for næringslivshistorie.

Porter, M. E. (1990). *The competitive advantage of nations*. London, UK: The Macmillan Press LTD.

Powell, W. W., & Grodal, S. (2005). Networks of innovators. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

Raasen, B. (2008). *Tid for integrert handling*. Norwegian Petroleum Directorate.

Rogers, E. M. (2003). *Diffusion of innovations*. New York, NY: Free Press.

Røvik, K. A. (1998). *Moderne Organisasjoner. Trender i organisasjonstenkingen ved tusenårsskiftet*. Bergen, Norway: Fagbokforlaget.

Røvik, K. A. (2007). *Trender og Translasjoner. Ideer som former det 21. århundrets organisasjon*. Oslo, Norway: Universitetsforlaget.

Schreyogg, G., & Kliesh-Eberl, M. (2007). How dynamic can organizational capabilities be? Towards a dual-process model of capability dynamization. *Strategic Management Journal*, *28*(9), 913–933. doi:10.1002/smj.613

Simon, H., & March, J. G. (1958). *Organizations*. New York, NY: John Wiley and sons, Inc.

Wahlen, M., Landmark, T., Sandven, K., Høydalsvik, H., & Hellebust, A. (2005). *Utredning om konsekvenser av omfattende innføring av edrift (integrerte operasjoner) på norsk sokkel for arbeidstakerne i petroleumsnæringen og muligheter for utvikling av nye norske arbeidsplasser*. SINTEF.

Zaltman, G., Duncan, R., & Holbek, J. (1973). *Innovation and organizations*. New York, NY: John Wiley and Sons.

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Chapter 9
Good IO-Design is More than IO-Rooms

Berit Moltu
Norwegian University of Science and Technology, Norway

ABSTRACT

'Integrated Operations' (IO) is about employing real time data and new technology to remove barriers between disciplines, expert groups, geography, and the company. IO has been associated with so called IO rooms. IO is technology driven, but is neither room nor technology deterministic. A network understanding of IO, based on Science and Technology Studies (STS), gives a process of different actants chained in networks, pointing the same directions by the same interests, to obtain the anticipated effect as is comes to efficiency and good HSE results. This chapter develops the seamless web of the IO design and describes good design criteria based on studies in Operational Support Rooms (OPS) in a Norwegian Oil Company. This process of the heterogeneous engineering of IO is not to be seen as technology implementation rather than technology development. This chapter points on how the seamless web of the IO design might contribute to good working conditions.

INTRODUCTION

The oil and gas industry is undergoing a fundamental change in important business processes. The transition is made possible by new and powerful information technology. Traditional work processes and organisational structures are challenged by more efficient and integrated approaches to exploration and production. The new approaches reduce the impact of traditional obstacles – whether they are geographical, organisational or professional – to efficient use of an organisation's expertise knowledge in decision making (Kaminski, D. 2004; Lauche, Sawaryn & Thorogood, 2006; Ringstad & Andersen, 2007

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Descriptions of the new approaches exist elsewhere (e.g. Upstream technology 2007), and will not be repeated here. The approaches can be subsumed under the heading Integrated Operations (IO). Numerous definitions of IO exist in the industry. In this company (2007) IO is defined as:

New work processes which use real time data to improve the collaboration between disciplines, organisations, companies and locations to achieve safer, better and faster decisions.

It is generally assumed that improved decision making processes will in turn lead to increased production, less downtime, fewer irregularities, a reduced number of HSE-related incidents, and a more efficient and streamlined operation in general. In this chapter we study four different IO solutions that create a working environment for decision-making, to look for correlations between IO designs and effectively and production. These are the issues addressed in this chapter.

The fundamental changes in work execution as a result of IO are illustrated in Figure 1 and are briefly described:

The old 'assembly line' work mode is seriously challenged by IO. More tasks can be performed in a parallel fashion, thereby reducing total time consumption. From a decision making perspective, parallel work execution means a more iterative and relational process.

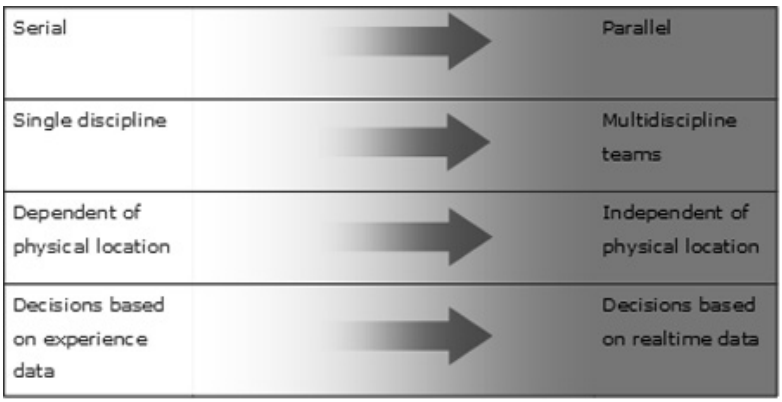
Multidisciplinary teamwork becomes more critical as the availability of real time data increases and work is performed in a parallel fashion more or less independently of physical location.

Real time data at different locations make it possible for personnel at these locations to cooperate based on a shared and up-to-date description of the operational situation.

Videoconferencing and ready access to data and software tools reduces the need for specialists to be on location. This increases the availability of expert knowledge for operational units, and reduces the time it takes to muster the experts.

The diverse and fundamental changes associated with IO require good design of IO rooms or operation support (OPS) rooms used for operation and maintenance activities in the offshore oil industry. This chapter is based on an empirical study of four different OPS-rooms or IO-designs (e.g. the fields of A, BA and BB, C and D) in an attempt to catch a best practice of IO design in terms of correlations with efficiency and productivity in the four different assets studied. The chapter shows that the most IO mature design correlates with efficiency. Good design criteria for the process is developed in this chapter. Based on the empirical study of the most IO mature design among the 4,

Figure 1. Changes in work execution as a result of IO (Andersen & Ringstad (2007), Moltu, Ringstad & Guttormsen (2008))



an argumentation on how this design was giving a good working environment based on the psychologically job demands from Einar Thorsrud and the Norwegian Working Environment Law § 12. The underlying assumption that better decisions gives more efficient and gives better HSE results, invites to a final discussion on different ways to understand the term decisions.

ACTOR NETWORK THEORY, A NEW WAY OF SEEING ROOMS AS NETWORK

In this study perspectives from Science and Technology Studies (STS) are taken into the field of HSE to describe an IO design. The collaboration between onshore and offshore, which is the main purpose in this study, makes us focus upon the work arenas onshore and the work arenas offshore that are most frequently in communication. The OPS unit as an organizational unit is now made possible over geographically disparate spaces by online videoconferencing and shared workspaces. This makes us focus on the so called operation support (OPS) rooms, i.e. in fact the OPS – room became rather much the icon of IO. In the Actor Network Theory approach (ANT), (Latour 1986, 94), we see rooms not only as limited to the physical space within four walls. This perspective, and the online video links and shared workspaces that the fibre optic cables enable us to use, makes us look upon an OPS room as a network or a chain of different rooms see Figure 2.

But looking a bit further, the iconic OPS rooms rather much contains of a broader IO design than just a network of rooms enabled by fibreoptic cables and ICT.

STS makes us see the OPS-room not merely as a physical room, but as a network or a chain of different elements. Inspired by ANT the OPS-rooms are seen as a process and a chain of network between different physical locations, different ICT-solutions, different organisational and managerial models, and new working practises, all supposed to support the current operations see Figure 3. This makes a broader IO design which is supposed to support and create new ways of working based on real time data, online communication and across geographically distance. This opens up for transparency in solutions e.g. to open up frozen borders between different departments, different disciplines, different geographical locations, management and employers, ICT and new ideas of what a room is.

Figure 2. OPS-rooms seen as a network of rooms (Moltu 2006)

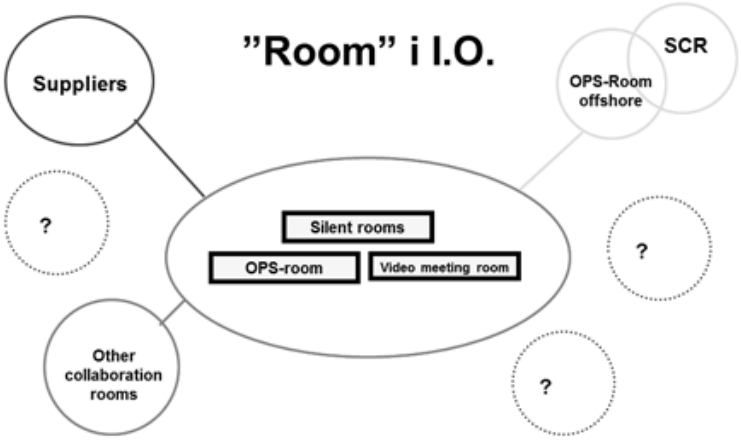


Figure 3. IO design as heterogeneous networks and a seamless web between different elements (Moltu 2006)

Asset	A	BA & B	C	D
IO maturity	Very mature	Medium mature	Immature	Not in use

The Seamless Web of Heterogeneous Engineering: A New Approach to IO Design

The interplay between technology and organization, might be seen as "a seamless web" (Callone, 1986) of how to develop, use and operate this technology e.g. a network of different actants human and nonhuman and how they chain in different "heterogeneous engineering" (Callone 1986).

IO design is very much about the development of new complex technology, with a lot of different choices and controversies on the issue of OPS-support rooms. To study the local community of practice (Levy and Venge, 1985) in greater depth where this technology is in use; their interactions, and negotiations of different interests and struggles, gives an important input to the understanding of the pros and cons of different IO designs. Our study will show that neither room nor technology is sufficient for a good IO solution. Neither room nor technology determinism is sufficient ways of understanding successful development of IO. There is a need for an innovative design based on some design criteria.

In studying the communities of practice in the OPS-units, we see this is "a messy matter" (Law, 2004). One of the main activities of researchers is to tidy up the mess, and traditionally linearity in-between categories has been one way to "tidy up". In STS analysis a starting point is to identify the most important groups of actants (Bijker & Pinch 1985) and the important controversies in an IO design. When we studied the different designs we noticed considerable variety in terminologies in relation to different solutions. Operation support room, IO room, Interaction room, Meeting room, Cinema, Operation window, High Tech, Big Brother, Landscape Office and Conference room were among the different names. It was interesting that some of the names corresponded with the different solutions and uses of IO designs. The IO room on asset A, which was the most IO mature asset, was often called the High-tech room or, as some of the people resisting the solution of online videoconferencing in the room named it, the Big Brother room from the reality television series where cameras follow the inhabitants of a house throughout the day and night. On asset C they named the room the Cinema, in relation to it being a dark room with dark curtains always drawn together and people coming in to sit on the chairs fastened to the walls, as in real cinemas, watching what was going on the screen in a meeting somewhere else. The different ways of naming the rooms tells a lot about the controversies in the design and practice of IO.

This unclear naming of the rooms inspired the oil company to make a list of the classifications of the different rooms as Meeting room, Advanced meeting room, Collaboration room, OPS-room, SCR, or Operation Centre with an increasing complexity and possibility for interaction. This was a way to describe the best practice. The OPS-room was here defined as a collaboration room with permanent workstations and capacity for 24/7 operation.

Time and Space in "Glocal" Workplaces

In the literature of new work life and more flexible communication between people due to the rise of the information age (Giddens 1991, Castells 1996, Sennett 1998, Beck 2000), it is stated that time and space do not matter anymore. In our study we see two different trends; an expanding global collaboration across geographical and temporal (time) zones in addition to an integrated collaboration across disciplines within the OPS-rooms based on real-time data. We call this a Glocal workplace, e.g. a workplace that is both local and global at the same time (Moltu & Gjersvik, 2006).

The paradox of IO, which is assumed to make geographical distance no longer matter, has been an extended focus on the physical room and the new collaboration arenas. In this study of the IO design it may be concluded that place does not matter as these designs make us able to work across geographical distance. However, what really matters is time. IO design makes an extended focus on real-time data, and the possibility to work together in real-time over distance by online videoconferencing. This is due to the work process in an OPS unit which reflects the 24/7 operation of an offshore platform organisation. This time dimension is what creates the extended focus on people working together in new collaboration arenas as OPS-rooms, and at the same time working through online videoconferencing and real-time data over distance but almost continuously online.

In other work processes the focus on physically meeting in collaboration arenas might be less important than in the OPS unit, and newer technology such as UCP (unified communication platforms) in portable PC's might undermine the need for rooms. We see these not as either / or but rather as supplementary technologies that provides more and needed flexibility due to the demands of some work processes.

THE MOST MATURE IO DESIGN GIVES HIGHEST EFFICIENCY

Based on the success criteria (a process of different actants chained in networks, pointing the same directions by the same interests, to obtain the anticipated effect as is comes to efficiency and good HSE) in the IO design in operation and maintenance, we classified the five different assets according to IO maturity (Figure 4). We found that at that time, asset A was the most IO mature, which means that they had developed the most extensively IO design as it comes to whether all the elements points in the same direction. The full potential of the IO design is not possible to achieve if some elements are missing or heading another direction than supporting the new way of working strategically chosen. Asset BA and BB developed an IO design to a moderate degree as it comes to the question of all the elements in the IO design, which means they have a middle-ranking IO maturity. C that used the IO design only to a little degree, was classified to be immature. D at that time had not yet started developing an IO design.

Survey of Effectively and Productivity Based on Internal Criteria for Operation, Maintenance, and Modifications in 5 Different Assets

Based on the company internal best practice criteria1 on operation, maintenance and modifications (named AR 12 now FR 06), a surveys were made for the same assets in relation to (a) efficiency in operation and maintenance work, (b) optimisation of production, and (c) management of asset integrity and (d) technical disciplines performed in the company in 2005/6.

This survey was conducted with 43 participants from the 5 assets in Operations North, where eleven participants came from A, eleven from BA and B, eight from C and seven from D. Among the people

Figure 4. The maturity of 5 different IO designs (Moltu & Golden Sæther 2006)), (Asset B was not satisfied with their solutions of today, asset C was satisfied)

	A							BA og B						
	#	Impr.		Potensial				#	Impr.		Potensial			
Tot 11		Y	N	1	2	3	4	9	Y	N	1	2	3	4
W	8	VIII	-	-	I	V	II	5	III	II	-	IV	I	-
X	7	VI	I	-	I	II	IV	6	VI	-	-	III	I	II
Y	6	IV	II	-	-	IV	I	6	II	IV	III	I	II	-
Z	8	VIII	-	-	I	VI	I	6	VI	-	-	IV	II	-

	C							D						
	#	Impr.		Potensial				#	Impr.		Potensial			
8		Y	N	1	2	3	4	7	Y	N	1	2	3	4
W	8	VI	II	-	IV	IV	-	5	IV	I	-	III	II	-
X	8	VI	II	-	V	III	-	5	V	-	I	III	-	I
Y	7	I	VI	I	III	III	-	4	II	II	II	-	I	I
Z	7	VI	I	-	I	IV	-	5	V	-	I	III	I	-

in the survey population, were the OPS leader, O&M leader, DVM leader, Production leader, and other engineers and planners, all central persons in the OPS unit.

The four questions asked were:

- **W:** Did the use of the IO design contribute to efficiency in the operation and maintenance processes by the possibility for transferring data onshore?
- **X:** Did the use of the IO design contribute to better online collaboration to optimize production?
- **Y:** Did the IO design contributed to condition based maintenance work?
- **Z:** Has the IO design contributed to better management of asset integrity and technical disciplines performed?

In addition the informants were asked to give examples on how the IO design has had an effect and to grade the extent to which the assets had a potential for improvement against these four questions A-D. 1.= very large potential for improvements, 2=large potential for improvements, 3=medium potential for improvements and 4=small potentials for improvements (see Figure 5).

The interesting first answer is that all assets go towards 'yes' when asked if IO design could have some positive effects on effectivity and productivity, (e.g. answers on the questions from W, X and Z). When it comes to the question Y, condition based maintenance, the answers were not so clear from asset B and C.

The potential for improvements are interesting to correlate with IO maturity. Asset D reports the largest potential for improvements in all areas. They had hardly started implementing the IO design. Asset C does also have a large indication towards medium potential for improvements. Asset B was very early to test out production optimisation before one started to talk about IO design, but they have not achieved the most mature IO design yet. On the other questions they report large potential for improvement. Asset A reports the least potential for improvements of the four assets. Against the question of optimisation of production, asset A reports they have come as far as they are able at that point.

This together makes us believe that there is a correlation between the IO design (high IO maturity) and achieved improvements in effectivity and productivity. Furthermore that the less IO mature assets (D and C) have a larger potential for improvements and the most IO mature (A)

Figure 5. IO maturity vs. effectivity and productivity. #=number of informants. Question W-Z. improved effectivity by IO design; Y=yes, N=no. Potential for further improvement in effectivity & productivity; 1=Very large, 2=Large, 3=Medium, 4=Small potentials for improvement

Asset	A	BA & B	C	D
IO maturity	Very mature	Medium mature	Immature	Not in use
Potentials for improvement	Medium to little	Large to very large	Large	Large

has a lesser potential for improvement. BA and BB have a moderate potential for improvement and has also a moderately IO mature IO design (Figure 4).

THE MOST MATURE IO DESIGN GIVES A GOOD WORKING ENVIRONMENT

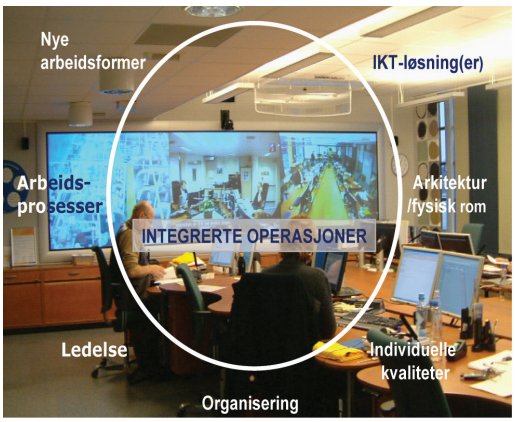
Then how does a mature IO design relate to a good work environment? The Norwegian work life researcher Einar Thorsrud developed the "Psychological job demands", for a good work environment. These demands are very well researched and verified, and is still going strong. In the Norwegian work environment law AML §12.2 we see is based on the research and results of these job demands. These are:

- Employees need to have a certain kind of content and variation in the job,
- Employees need to learn and develop in the job,
- To have a certain degree of autonomy,
- To achieve acceptance, respect and support, a need to see a correlation between your work and the surrounding context
- A need to see the job to be in line with a future wished for

For the OPS units at the asset A, we do find that the criteria are present at this workplace, both by our participative observation, but also by the way the employees describe their workplace

There were a certain kind of Involvement of employee, they had self-synchronised teams, employees were empowered to do the job. There was a rather low hierarchical organisation between leader and employees, there was a high degree of trust among them. The leaders had recruited and trained the right people. First line manager was indeed a local enthusiast for the IO design, continuously maintaining and developing it. (see Figure 6).

Figure 6. "Integrated operations is about the elements in the IO design, this is a dynamic process that must be balanced, that means all the elements must point or go in the same direction"



DESIGN CRITERIA: TRANSPARENCY, SIMPLICITY, AND SIMILARITY FOR FUN AND FLEXIBILITY

On the basis of this study, some main design criteria for a good IO design were developed. These are;

- Transparency
- Simplicity
- Similarity
- To achieve Fun and flexibility

The company internal guideline GL 0342 on IO rooms describes best practice in establishing new IO rooms, and is partly based on these studies. However, in most cases rebuilding of existing rooms is the norm. These design criteria might be used in the creative work of rebuilding in addition to design according to good human-factors analysis.

In the following section we will show how these design criteria are translated into the elements of the IO design. Early studies of OPS-rooms looked to the literature and experiences from control rooms to find the best designs. This is to look in the wrong direction for inspiration. There are completely different ways of thinking behind these environments, based on closed loops of cybernetics and the control and regulation of these. System theory was the main theoretical approach and source of inspiration for them. That is not compatible with the criteria of transparency needed in IO, for example. In the following we will try to outline this shift in thinking and explain its meaning. This is a continuously process of sysifos, a never ending story.

ICT

In this study a lot of different ICT solutions were available and used in a different manner within the different assets. These were videoconference, "duostrøm", video projector, back projection screen, CCTV, OS-station, permanent work-stations, PC, smart boards, document camera, visiwear, telephone conference named "padda", digital camera and different telephone solutions such as person call, stationary phones with an call via AV offshore, and mobile phones onshore. Among these technologies one seemed to be the most important in the IO design, namely the online videoconference between on and offshore. A huge back projected screen gave an impressive visual quality that gave the feeling of sitting next-door. As an operator on A stated, "it was just to look up from your desk to see if someone offshore was there. It was if they were sitting in the room next-door just divided by a glass wall". Excellent visual and sound quality (muted when not needed) created a very close feeling. The online videoconference makes the physical distance between on and offshore more transparent, and merges the gap between "us and them", onshore and offshore, to an "us in the OPS-unit".

This technology makes it very easy to get access to the people offshore and vice versa. The fact that the conference is online is also an argument for simplicity, avoiding the technological fumbling most people experience by starting such a system. There needs to be, of course, a similarity between on and offshore solution to profit from it.

In addition to the online videoconference between onshore and offshore, there were sometimes additional needs for more 'traditional' videoconference meetings, e.g. a support room with videoconference facilities located next door used more for meetings. For this way of working, which is for limited periods, there is not the same need for such good quality images on the screens. A video projector might well be used for this purpose, but not for the online videoconference due to noise produced that might constitute a working environment hazard over long periods.

Architecture

In the old control room model, which was looked into in the early days of IO, no daylight or windows were allowed due to ideas of security and

control but also because of daylight reflections on the screens. In the new design, transparency means also the importance of daylight and view over the surrounding scenery. Better technical quality, especially on back projection screens, has helped to enable this concept. This is very important for permanent workplaces to give operators energy during the day, especially in OPS-rooms where more intensive concurrent ways of working dominate.

The flexibility needed for the preferred way of working is made available by designing not one OPS room but several rooms in a group, where the OPS room is the main room and there are support rooms as video/meeting rooms and sufficient quiet rooms, surrounded by an open landscape office and/or cellular offices. Enough volume/space of the room is crucial for fresh air needed during long days.

Transparency in architecture also means the use of glass doors and glass walls between the different rooms. This gives a quick overview of who is in, without necessarily hearing everything that is being said.

Way of Working

One of the main success criteria in the IO design is the online videoconferencing to secure the transparency between onshore and offshore. This is muted when not actively in use, to be able to see who's passing by, being able to catch them for a question or a talk, or just to have an idea of what is going on in the office offshore. These are some of the advantages. The online function follows the very important decision to have the OPS room as a permanent workplace in contradiction to a meeting room you enter only for a planned meeting. This way of working underlines what is most important here, the work processes and the value creation between onshore and offshore. This is to be able to rapidly mobilize discipline experts to a problem when it occurs. This might be either experts already in the room or experts with their permanent workplace either in nearby open landscape office areas or cellular offices. This way of working enables a more cross or trans-disciplinary way of problem solving, which might lead to quicker and better, maybe even safer, decisions. The access to more online or real-time information also enables more proactive ways of working in contrast to the more reactive ones. These new ways of working inspired by concurrent design are also about doing things more in parallel instead of the more serial processing way of working, both because of access to more people in the work arena but also due to more information and more ICT tools available. This might give a valuable and more holistic picture of the situation that might help solve more complex problems. This way of working might be considered as more simplistic in comparison with a more traditional bureaucratic method. One has to carefully consider who shall have their permanent workplace in the OPS room, and who shall not. It is important to note that the OPS room is merely a room for a collective concentration, and for more individual concentration work one has to use the small "focus rooms" nearby, or for meetings that do not include everyone in the OPS-room one uses the nearby videoconference room. With that in mind some of the discussion of "noise" is directed in the right direction. This way of working is a very social one, allowing more interaction with more people than traditionally, and is a design that focuses more on the communities of practice but in new ways that include not only face to face communities but also a new hybrid community.

Transparency in the way of working is about more information and knowledge sharing, and makes the more traditional ways of coordination to a certain extent unnecessary.

Work Processes

The work processes in the company, based on the value creation work done between onshore and offshore in Operation and Maintenance is, at an

overview level, more constant and not considered to be changing considerably by an IO design. It is more the way of working to solve these work processes that are changing from a serial-functionally divided way of working to a more integrated transdisciplinary way of working. However, the work process is what underlies and constitutes the need for an OPS-room and online videoconferencing facilities. The work processes between onshore and offshore operations are also what constitute the need for powerful workstations (operation systems), that are more permanent and based in a physical room rather than laptop-based. This constitutes a need for the physically open working arenas that OPS-rooms are. The flexibility has some limitations here; not all these work processes might be achieved using laptop-based solutions.

Organisation

There has to be symmetry in the organisation between onshore and offshore to secure good integration, either through symmetrically-organised management teams that are connected via online videoconference or if the OPS unit is an integrated organisational unit with members from both onshore and offshore. There is also an unique opportunity to build confidence between sea and shore by integrating personnel by rotation. The OPS room might be in a matrix organization, where the OPS-team is surrounded and supported by the disciplinary hierarchy of the discipline ladder, whose knowledge might be mobilized when needed. In that way the OPS-room might function as a kind of hub or node, bringing the network of different experts together. One of the main capabilities to develop is the continuous maintaining of how to identify and mobilize the right competence at the right time. A low bureaucratic, self syncronised team is to a certain degree preferred organisational structure. A traditional hierarchical division of labour requires a lot of information sharing and high transaction cost of coordination. Self-synchronized teams have a shared situational awareness that might be very useful for quality decisions. For quick and quality solving of problem, first line employees should be empowered to operate with high autonomy on certain issues. For that purpose one need common goals, values, competence and to be given confidence .

Leadership

In IO design, leadership is required to go from a more hierarchical, controlling role that gives instructions towards a more open, process oriented role based on collaboration with skilled knowledge workers or discipline experts. Decisions should be taken at the lowest possible level .

Collaboration requires an attitude of equality and respect which might be demanding. Another aspect of organisation and leadership in IO design is that a larger degree of self-synchronisation is also required from the team in the OPS-room.

In addition to the OPS team there are experts not normally sitting in the OPS-room. A new capability will be to facilitate the expert knowledge, to mobilize and ensure that the right person is in place at the right time. To be able to achieve this a good overview of the knowledge field and the disciplines is needed. IO based strategic thinking is also important, which is the attitude to see and seek possibilities based on IO design in all the daily decisions.

This is much consideration about creating new interdisciplinary knowledge, new possibilities together with highly skilled knowledge workers and to facilitate possibilities for different disciplinary knowledge to meet in an interdisciplinary arena.

Attitude

Even though we see a tendency that people that have been exposed to these new open work arenas seem to like it and have fun even if they were initially sceptical, it's a lot about attitude, openness to new ideas and new ways of working. Most

people, after a while, do not want to go back to the more traditional forms of working, though some people never find it truly comfortable to work in this way. One success factor in the IO design is the possibility to recruit people that would like to work in this way instead of forcing people that are thinking in another direction. It concerns going from a protective attitude towards work and your colleagues, towards a more productive one, e.g. to see that something new might be created in the meeting between other people other disciplines, other experiences. A lot of the value creation is in this understanding and achievement.

UNDERSTANDING IO AS CHANGE MANAGEMENT

By identifying the different controversies one also identifies the interests that are connected to the controversies, and the constellations of interests that the different actants are chained within. Interests are to be seen as the "driving forces" for changes. Interests are what makes things happen both in a positive and a negative way, e.g. interests are also what make things not happen. If one wants to understand the organisational development aspects of an IO design, one has to understand the main interests. And if one want to achieve organizational change one has to be able to play with the main interests or to be able to play the game, to link in with the different interests in different enrolments and translations (Latour, 1986) to make a strong enough chain to be able to achieve Change Management. If not it is all in vain.

From Cellular Office to Landscape to OPS-Rooms: A Change in the Drivers for Change

The IO design exemplified by the OPS-rooms and its focus on the physical work arena differs from the more traditional change from cellular office to open landscape areas that has been going on in the same company for some years. The drivers for change in these processes have been cost-cutting due to reduced area. But in IO this is not the case. Here you have the shift from open landscapes to the particular OPS-room, and the drivers for change are not cost-cutting, but increased value creation and better HSE results due to a better use of the company's competence and thereby better decisions through increased interaction across disciplines, licenses, companies and geography. This is achieved through new ways of planning, organizing and performing the jobs made possible by new ICT. The new thing in this shift is that the IO design is ruled or shall support the work processes. This was not the case in companies' earlier practice, planning changes from cellular office to open landscape, indifferent to the work processes going on in the rooms. Here the main aim was to reduce costs due to area. Focusing on for instance optimisation of production in the new IO designs gives another bottom-line.

Participation in IO Designs, Based on New Legitimating

Working with understanding the success criteria of the IO designs and the best practices translated into company internal guideline documents, questions the issue of participation in the change processes of designing new work arenas as OPS-rooms. Who shall participate and when and in which way are central questions. Recent research on participation shows a shift in the legitimizing of participation from the more traditional legitimating as democracy and economically-based arguments as efficiency, to a new way of legitimating participation based on knowledge (Moltu 2003). This gives new ways of participating and from other groups of actors than earlier. Relevant to the IO design is that expert knowledge and best practice are actants that participate in the IO designs based on this knowledge argumentation more than the users. End-users also need to participate not only

based on their democratic rights as one is used to, but based on their experiences as input to the experts. Much experience and research shows that it's wise to operate within a collaborative tradition between management and employees to get good results and use of resources. If more collaborative, cross-disciplinary ways of working as discussed in this study is believed to give value creation and better HSE results, then it is finally a management decision to implement this model.

In the IO change processes we have seen conflicting interests between management representatives and trade unions. The search conference can be a useful tool in order to overcome these "change process barriers". The search conference can create openness among the participants (show that things are what they appear to be); create an understanding of a shared field (the people present can see they are in the same world/situation); create psychological similarity among the representatives; and it can generate a mutual trust between parties. All these elements are found to be important in order to achieve effective communication within and between groups (Asch, 1952), and in this case to bring the planned change process forward in a constructive direction.

CONCLUSION

Change and design in Integrated Operations is about both architecture, ICT, work processes, ways of working, organisation, leadership and attitudes. In this chapter we have identified some criteria for good IO designs when we handle these elements. These include Transparency, Similarity and Simplicity. These criteria are supporting a design for flexibility and fun. In five different IO designs studied in an OPS-room setting we saw a correlation between IO maturity in this design and effectively and productivity in addition to a good working environment based on the psychologically job demands. Analyses of the results on efficiency and job makes us conclude that the assets performing good when it comes to efficiency, also performs good on a good work environment as it comes to psychological job demands (Thorsrud, 1977, AML §12). We attribute this to a transparent workplace design. The interesting next discussion based on this study is how IO design also may influence risk management. We believe that a online and proactive job practice also might positively influence risk level.

REFERENCES

Asch, S. (1952). *Social psychology*. Englewood Cliffs, NJ: Prentice-Hall. doi:10.1037/10025-000

Beck, U. (2000). *What is globalization?* Cambridge, UK: Polity Press.

Bijker, W. E., Hughes, T. P., & Pinch, T. (1987). *The social construction of technological systems*. Cambridge, MA: The MIT Press.

Callone, M. (1986). In Law, J. (Ed.), *Some elements of a sociology of translation: dOmestication of the scallops and the fisherman* (pp. 196–229).

Castells, M. (1996). *The rise of the network society*. Oxford, UK: Blackwell.

Emery, M., & Purser, R. E. (1996). *The search conference – A method for planning organizational change and community action*. San Francisco, CA: Jossey-Bass Publishers.

Giddens, A. (1991). *Modernity and self-identity*. Stanford, CA: Stanford University Press.

Kaminski, D. (2004). *Remote real time operations centre for geologically optimised productivity.* Chapter presented at the AAPG International Conference, Cancun, Mexico.

Latour, B. (1986). *Science in action*. Cambridge, MA: Harvard University Press.

Lauche, K., Sawaryn, S. J., & Thorogood, J. L. (2006). *Capability development with remote drilling operations.* Chapter presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Lave, J. Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Law, J. (2004). *After method: Mess in social science research*. London, UK: Routledge.

Moltu, B. (2003). *BPR in Norwegian! The management concept of business process reengineering (BP) as a culturally praxis.* (Nr 2004:81) PhD Thesis, NTNU, Trondheim, Norway

Moltu, B., Ringstad, A. J., & Guttormsen, G. (2008). *Consequence analysis as organisational development.* ESREL 2008.

Moltu, B., & Sæther, G. G. (2004). *Betre samhandling mellom hav og land Evaluering av OPS-rom i HNO*. SINTEF Teknologi og samfunn rapport.

Ringstad, A. J., & Andersen, K. (2007*). Integrated operations and the need for a balanced development of people, technology and organization*. Chapter presented at the International Petroleum Technology Conference, Dubai, UA.

Sennett, R. (1998). *The corrosion of character. The personal consequences of work in the new capitalism.*

StatoilHydro. (2007). Integrated operations in StatoilHydro. *Monthly Newsletter*, May 2007.

Upstream Technology. (February 2007). *Interview with Adolfo Henriquez, manager – Corporate initiative integrated operations, StatoilHydro* (pp. 36-37).

ENDNOTE

1 AR 12, Best practice documents on operation, maintenance and modifications. Today named FR 06.

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Section 3
Planning, Concurrent Design, and Team

Chapter 10
How to Implement Multidisciplinary Work Processes in the Oil Industry: A Statoil Case

Tom Rosendahl
BI Norwegian Business School, Norway

Asbjørn Egir
Astra North, Norway

Erik Rolland
University of California, USA

ABSTRACT

This chapter explores possibilities for using Concurrent Design at Statoil, seeking to understand how they should proceed in implementing this kind of work, and consider potential pitfalls of using this method. The authors offer ideas that can minimize the time required to implement the multi-disciplinary approach of Concurrent Design. Few companies have the requisite knowledge and skills required to implement this method effectively. Concurrent Design requires preparation and dedication to planning and implementation, along with adequate resources. It requires numerous changes in the organization's and in the employees' mindsets. Top management, department heads, project managers, and employees must adapt and change their work processes.

1. INTRODUCTION

During the past few decades, organizations have increasingly focused on how to structure work (Morton et al., 2006; Ford et al., 2003; Smith et al., 1997; Flin, 1997). This has created a multitude of changes in such firms as Statoil, a major Norwegian oil and gas company, as well as across the entire petroleum industry (Sharp et al., 2001; Flin, 1997). Increasingly companies organize employees in teams and work groups, to meet challenges and to create a competitive advantage (Andres, 2002; Morton et al., 2006; Ford et al., 2003; Smith et al., 1997; Sharp et al.,

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2001). Statoil seeks to structure work in a way that allows the best use of employees to achieve a more advantageous international position (Reinertsen et al., 1991). Several oil companies on the Norwegian continental shelf have implemented Integrated Operations (IO) as a strategic tool to achieve safe, reliable, and efficient operations (Skarholt et al., 2009; Reinertsen et al., 1991). There are a variety of concepts describing IO, also called e-Operations and Smart Operations. IO allows for a tighter integration of offshore and onshore personnel, operator companies, and service companies, by working with real-time data from the offshore installations.

The Norwegian Ministry of Petroleum and Energy (2004) defines IO as: "Use of information technology to change work processes to achieve improved decisions, remote control of processes and equipment, and to relocate functions and personnel to a remote installation or an onshore facility". IO is both a technological and an organisational issue, focusing on the use of new and advanced technology as well as new work practices. According to Henriquez et al. (2007), the IO technology implementation is not considered to be a major obstacle in Statoil. The most challenging issue is to develop new work practices and change management to be able to fully explore the potential of working as a integrated company.

How technology is able to coordinate and communicate tasks within virtual teams is of great importance (Andres, 2002; Kirkman et al., 2004). The IO technology consists of high-quality video conferencing, shared work spaces and data sharing facilities (Skarholt et al., 2009). These arenas include collaboration rooms for rapid responses and decision-making. They are designed with video walls to share information and involve people in discussions, having eye contact with each other both onshore and offshore (Kirkman et al., 2004). IO technology is characterized by vividness and interactivity. According to Steuer (1992), vividness is the ability of a telecommunications medium to produce a rich environment for the senses, which means having a range of sensory input (i.e. voice, video and eye contact), as well as depth of information bandwidth. In their study, Skarholt et al. (2009:821) found "that the use of collaboration rooms creates the sense of being present in a place different from one's physical location", a sense of "being there". The integration of people, work processes and even vendors is a high priority and a key success factor for major oil operators as well as operating service companies to succeed using IO principles (Hepsø, 2006).

In their ambition to achieve this potential, Statoil explored a method called Concurrent Design, to see if their way of structuring projects could be challenged (Reinertsen et al., 1991; Smith etal., 1997). Concurrent Design is a multi-disciplinary work method where all the elements of Integrated Operations are present, but in a planned and structured fashion. This method was originally developed for the space industry and Statoil seeks to use this structured way for creating and running multi-disciplinary teams in their new projects.

Many organizations are moving from a sequential work processes towards a parallel way of working (Flin, 1997). Forming multi-disciplinary or multi-functional teams plays a central role in this change process (West et al., 2004; Sharp et al., 2001; Flin, 1997). Organizations are more willing both to improve the existing resources and to improve the way they structure their work and work arenas. "The motivating premise underlying the use of these teams is that when representatives from all of the relevant areas of expertise are brought together, team decisions and actions are more likely to encompass the full range of perspectives and issues that might affect the success of a collective venture" (Van der Vegt and Bunderson, 2005; Sharp et al., 2001).

In organizations with a wide range of disciplines that have specialized knowledge and expertise, organizing and structuring the work

in more multi-functional and multi-disciplinary ways is a sensible and attractive option for many industries and companies (Van Der Vegt & Bunderson, 2005; Van der Vegt and Van der Vliert, 2000). The potential for gaining both a sustainable competitive advantage and a better work culture seem obvious, but the ability and the knowledge within the organizations to reach this potential are not always available, resulting in measurable benefits being elusive (Van der Vegt and Bunderson, 2005; Koufteros et al., 2001).

In crisis, people naturally form teams and work concurrently (Flin, 1997). The necessary knowledge is ready at hand when needed, and problems that arise can be discussed on-the-spot (Flin, 1997). However, under normal working conditions in large companies, the over-the-wall approach to multi-disciplinary tasks has been common during the past decades (Morton et al., 2006; Koufteros et al., 2001). Some work is done and then passed on to the next person or unit in the production line and so on, with minimal communication (see i.e. Clampitt, 2005). This sequential work order is still carried out today, and if often both less efficient and effective, and wasting organizational resources.

In order to solve complex problems, organization in the oil and gas industry typically require the integration of knowledge from such different specialists as geologists, system engineers, civil engineers, economists, managers, and drilling personnel (Kirkman et al., 2004; Smith et al., 1991). These organizations rely on the formation of complex teams, but how exactly should this work be organized? How can the individual experts contribute his or her special knowledge to help the organization achieve superior solutions, and how can such organizations make timely and consistently high-quality decisions? Realizing that not all tasks gain from being solved in a team environment, there is a need for a methodology that allows work to be completed in the most effective and efficient manner. This chapter explores key success factors in multi-disciplinary task groups and identifies relevant factors for implementing a multi-disciplinary work method (Smith et al., 1991; Sharp et al., 2001). Success means saving both money and time while achieving the best possible result. We describe a successful Concurrent Design implementation at Statoil. Section 2 describes the goals of our case study, and section 3 briefly includes the case setting at Statoil. The Concurrent Design methodology is reviewed in section 4, and the implementation results are summarized in section 5. Notable pitfalls are emphasized in section 6, before concluding remarks are given in section 7.

2. PROBLEM DEFINITION AND METHOD

The goals of our study were to enable more efficient and effective work processes through implementing Concurrent Design at Statoil. The case study followed the designing and implementing of a Concurrent Design pilot project for the early phase (oil and gas) field developments at the Gudrun/Sigrun fields in the North Sea. The study was investigative in nature, looking at a set of factors that may be viewed from several different aspects. As such, we chose to use a case study, since these types of studies typically constitute a proper research method for action research and organizational change processes (Yin, 2002; Kotter, 1996).

We followed the pilot project from early February until late June, observed the team during the first information meeting (a combined information meeting and training session), and then through eight follow-up sessions until the result was ready to be presented to the customer (Statoil). The authors took on a participant – by – observer role. During this period, we observed the meetings and sessions in a non-intrusive manner from within the meeting rooms.

A preliminary assessment tool (a questionnaire) was developed during this project. At the end of the project this questionnaire was made available

to all the participants of the team, including the customer and project management. Through the questionnaire, seven elements of the pilot study were assessed: Efficiency, the quality of inputs and outputs, the understanding of the full value chain, interdisciplinary communication, the quality of the product, interdisciplinary consistency, and the "fun factor". At the end of the pilot, an open meeting was held were the participants were allowed to openly share comments and remarks about the project, the product and the process. A brief summary of these results are presented in this chapter.

During the case study, we had numerous formal and informal discussions with the participants, the project manager and the customer regarding the Concurrent Design method and especially about how Statoil could use this method as their procedure for handling complex problems involving many different disciplines. We also had numerous discussions with the facilitator and the person responsible for introducing this method at Statoil, which provided us with valuable information. At the end of the project, we participated in the evaluation done by the management team and the facilitator where they discussed their experiences, and made concluding remarks regarding the future use of the Concurrent Design method as applied to their project at Statoil.

3. A BRIEF INTRODUCTION OF STATOIL AND BACKGROUND FOR THE PROJECT

In 1972, the Norwegian State Oil Company, Statoil, was formed, and two years later the Statfjord field was discovered in the North Sea. In 1979, the Statfjord field commenced production, and in 1981 Statoil was the first Norwegian company to be given operator responsibility for a field, at Gullfaks in the North Sea. Currently, the company has significant international activities outside Norway. The organization operates in 40 countries and performs exploration and production in 39 of these countries. It has approximately 30 000 employees with the headquarters based in Stavanger, Norway. 11 000 of Statoil's employees are based outside Norway. The company is the operator of 37 oil and gas fields on the Norwegian continental shelf and accounts for 80% of all Norwegian petroleum production. Statoil's portfolio outside Norway is growing, and the increased competition among the largest oil and gas companies is very strong. To be able to find new reserves and to win the competition for access to exploration acreage is becoming more important. The production profiles for the industry are bleak, which forces the question as to how can they achieve better results with better margins based on the resources and competencies they already have (Van der Vegt and Bunderson, 2005). The overall aim for Statoil is to find new solutions to be able to exploit its oil fields more efficiently. Organizing more efficiently and effectively than its competitors is believed to help Statoil establish a foundation for a competitive advantage both on the Norwegian continental shelf and internationally (Statoil Annual Report, 2007).

To improve the work processes, and quality of their decisions, and shortening lead-times to generate products, Statoil has decided to explore the possibility of using the Concurrent Design work method (Morton et al., 2006; Takeuchi et al., 1986). Earlier, Statoil worked according to a non-integrative method that was rooted in sequentially based work processes where every department "minded its own business" (Morton et al., 2006). The problem with this, however, was that when the work process needed to be coordinated, it often became apparent that the different departments did not have sufficient information concerning other areas of expertise – there was little or no inter-departmental knowledge transfer; this was one of the main reasons for introducing the multi-disciplinary work method Concurrent Design (Hayes, 2002; Smith et al., 1991; Takeuchi et al., 1986). Particularly, Statoil's problems became apparent when the different disciplines

met, and it was obvious that the various disciplines did not have sufficient knowledge and expertise regarding the other disciplines. This lack of knowledge transfer and lack of information can lead to bad decisions and a waste of time and resources because of numerous "cold" restarts in their work projects (Van der Vegt and Bunderson, 2005; Takeuchi etal., 1986). Statoil decided to conduct various pilot projects using Concurrent Design in the area of early phase field development, modifications and oil well planning.

By taking on these pilot projects using multidisciplinary teams, Statoil seeks to enable better decision-making and find faster solutions through collaboration and knowledge transfer between the disciplines involved in that specific project.

4. THEORETICAL BACKGROUND AND CONCURRENT DESIGN

In this section we will focus on Concurrent Design and teams as a driver in change management (Kotter, 1996). Concurrent Design is a multi-disciplinary work method combining the elements of people, process and tools in a new and more structured way (Clark et al., 1990). The results of using such an integrated method can be better decisions and faster solutions through a total system approach which includes integrating diverse knowledge and expertise early in the process (Øxnevad, 2000; Clark et al., 1990).

Every organization, one way or another, has been through some sort of change or change process, including those organizations that did not see it as necessary or never saw it coming at all. If an organization is about to change, either voluntarily or involuntarily, due to its surroundings, creating teams and team work methods can be a very effective way of handling such a change process (West et al., 2004). Katzenbach and Smith (1993), also argue that if an organization is facing major changes within its surroundings, team and multi-disciplinary work methods can play a crucial part in the process of dealing with and adapting to the new environment. When Statoil creates teams containing disciplines from several departments, it is a golden opportunity to bring the message to a lot of employees, and it creates groups of committed people (Van der Vegt and Van der Vliert 2000). These employees will put the message forward that we need to change to be able to maintain or improve our position in the future, and the way to do it is by working 'smarter' together using the Concurrent Design work method.

By using teams to both develop a new way of working and to bring the message out to their own discipline is a way to bring the message and the information to the whole organization in a very short time (Hayes, 2002). The Statoil management team has decided it is time to change the way they work. Trying to convince employees one by one will take too long. Using the different teams and their experience will not only take less time; it will also be much more influential. A group of people giving the same message as a single voice can be very convincing when presenting a potentially frightening message (Hayes, 2002).

Katzenbach and Smith (1993) also argue that team-based organization is much more open and positive when it comes to change and change processes. It is much easier for an organization that is based on a team structure instead of a hierarchical structure to respond faster and more positively to changes. Employees organized in teams are far more involved and have an active voice in what goes on in the team. They produce suggestions about how they can improve the way they are working and they listen very carefully to the other team members and their suggestions as well.

The Concurrent Design approach is based on the interconnection between the members of the team, the Concurrent Design process and the use of relevant tools early on in the process (Øxnevad,

Figure 1. An illustration of the integration of the three important elements in an organization; people, process and technology (Based on OLF, 2005)



2000). These three main elements are illustrated in Figure 1. The development of the operational method called Concurrent Design started at the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). The main principles of the method are listed in Figure 2.

The eight principles in Figure 2 are the bases of the Concurrent Design method (Øxnevad, 2000). When establishing a multi-disciplinary team (1), a total systems approach to the problem must be ensured. Bringing in all the relevant disciplines into the project makes sure that all the functional areas are covered. The team members are brought together in the same room to work in concurrent sessions. This makes certain that the disciplines have quick access to the relevant knowledge and have the opportunity to deal with the problems and the challenges in real time, faster than before. With quick and sufficient access to the relevant knowledge, it gives the disciplines the opportunity to challenge the parameters and the data early on and to work with the solutions in real-time (Hepsø, 2009). This will, in the end, save a great deal of time and consequently money for organizations that are able to structure their work in this more efficient way (Øxnevad, 2000).

Today, much of the time at work is spent in meetings that are often unproductive (see i.e. OLF, 2005). Concurrent sessions (2) give the team members an opportunity to perform design analysis and work in real-time (4) as well as working in close proximity with the relevant disciplines (Øxnevad, 2000). A special Concurrent Design working arena was constructed at Statoil for this purpose, and illustrated in Figure 3 below. The work arena in this figure shows four "pods', where members of the Concurrent Design team work. The center pod is reserved for the session lead, customer (3), and external participants (Danilovic, 2006). The rectangles along the wall are overhead display units controlled by the session lead, and where each can display any of the computer screens in the room (Øxnevad, 2000).

Using Concurrent Design, the customer is in the room to make decisions and to monitor the process and the progress (Danilovic, 2006). If it is necessary to make adjustments to the project or to look at new scenarios, the customer is in there, ready to make these decisions. The session lead plays an important role in the Concurrent Design methodology. This person has a prime responsibility to make sure that the communication in the sessions goes according to plan, that the objectives are being reached, and to involve the project manager and the customer whenever needed (Øxnevad, 2000).

All the relevant disciplines are in the room and the customer is present in the middle, able to make decisions and change the course of work, if necessary. In these sessions, the team members use high-end inter-linked computer tools (5) to perform their work (Andres, 2002). The disciplines use these tools to establish facts as early as possible (6). They share the data and the information with the other disciplines, and this enables them to have a high level of accuracy and an integrated system from early on in the process (7,8) (Øxnevad, 2000; Kirkman etal., 2004).

Figure 2. The eight principles of concurrent design (Based on Øxnevad, 2000)

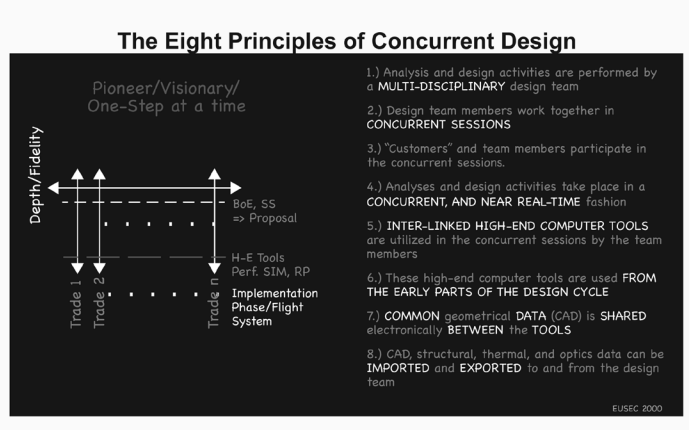
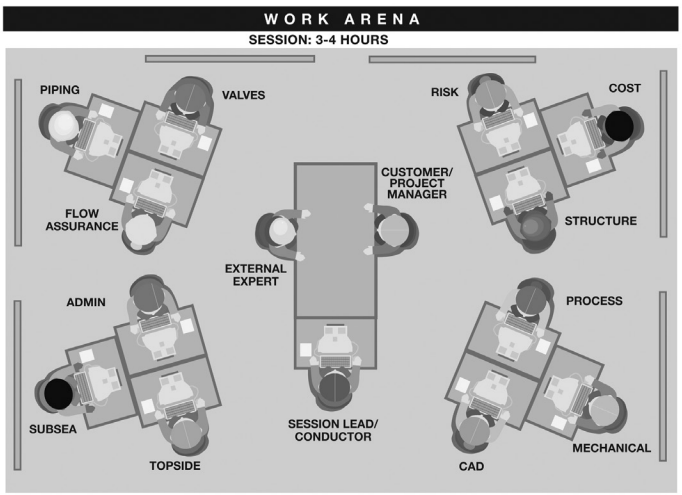


Figure 3. An example of a concurrent design work arena (Based on Øxnevad, 2000)



A team is never totally isolated, neither when it comes to its own organization and nor when it comes to their external relations. A specific team is a part of a larger organization and that organization gives the team a set of boundaries and rules in which the team can operate and function (Smith et al., 1991). The organization has a considerable amount of influence on how the team can perform its task and attain its goals. But this relationship also goes the other way; the team has a considerable amount of influence on the organization in which it is located. If Statoil is to successfully implement a multi-disciplinary work method, such as Concurrent Design, it needs to understand how the organization and the team work together and how they interrelate with other parts of the organization (Hayes, 2002).

5. RESULTS AND ANALYSIS

This section is organized in two parts. The first part summarizes data from the pilot study at Statoil. The second part relates the observations from this

study to Hackman's six elements of organizational support for implementing a multi-disciplinary work method, and they are the key to Statoil's further implementation and use of Concurrent Design throughout her organization.

Pilot Study Results

For the purposes of comparing the concurrent Design work method with Statoil's traditional work methods, we constructed a simple pilot survey to be used as a preliminary evaluation for this case study. A set of seven questions were asked, related to efficiency, quality, understanding the value chain, interdisciplinary communications, quality, interdisciplinary consistency, and the fun factor. We used closed–ended questions with Likert scale values ranging from 1 to 5; each associated with an "improvement scale" given in Table 1 below. We note that the scale is somewhat biased, in that the midpoint ("neutral") is not a score 3. However, this was communicated to the team members before the survey was taken. The questions were framed as "compared to past work projects, what type of impact did the concurrent design method have with respect to" each of the seven factors given in Figure 4. The full sixteen (16) team members answered all seven (7) survey questions.

Given the small sample size and therefore lack of a better statistical analysis of the data, we need to execute caution as to how to interpret the numerical results. In our opinion, these results should be viewed as indicators only, and an improved survey with proper statistical analysis would lead to more definite conclusions. Thus, the results outlined in Table 1 indicate that the concurrent design work method may lead much better interdisciplinary communication, as well as an improved 'fun factor" for the involved team members (as seen from both the higher average scores and the comparatively lower standard deviations for these questions). The team members' understanding of the full value chain seems to have been improved compared to traditional project work. Quality and interdisciplinary consistency seem also to be improved.

If Statoil wants to have effectively working teams, the teams need organizational support to be able to function properly and be an asset and a creative force throughout the organization. Hackman (1990) identified six aspects of organizational support provided by different levels of the organization. It is essential for Statoil to be aware of these six, different elements if the teams and the organization are going to function well together and to bring out the best from the relationship. These six elements will be relevant for Statoil when they start to implement Concurrent Design as their way of handling complex problems throughout the entire organization (Hackman, 1990). The six elements are:

- Clear targets
- Adequate resources
- Reliable information
- Training
- Regular feedback
- Technical support

Figure 4. Pilot survey results

Question		Average Score	StDev
Did you experience	**Efficiency** in your work?	3.38	0.72
Did you experience	**Quality** in your results and output?	2.63	0.72
Did you experience	**Understanding** of the full value chain?	3.50	0.73
Did you experience	**Interdisciplinary** communication?	3.88	0.50
Did you experience	**Quality** in the final report?	2.80	0.86
Did you experience	**Interdisciplinary Consistency** in the final report?	3.00	0.97
Did you experience	**Fun Factor**?	3.69	0.70

We have integrated these elements in our evaluation from the empirical data collected at Statoil below.

Clear Targets for the Concurrent Design Teams

Statoil needs to formulate and articulate a clear and well defined target for what the team or teams are supposed to do (Hackman, 1990). It is impossible for a Concurrent Design team to function properly at its best if the target is communicated poorly to the participants. The target will certainly vary depending on the projects, but the objectives and the purpose from the Statoil management still need to be clear and well defined for the team to reach its potential. The team needs to understand the objectives and the discussion behind them to be able to work as a well-integrated and fully functional Concurrent Design team (Smith et al., 1991).

The results from our investigation into the Gudrun/Sigrun pilot point in one direction. Both the results from the measurement of "interdisciplinary consistency" and "the understanding of the full value chain" reflect this. The highest improvement, by far, was the element of "interdisciplinary communication". The ability to talk and explain to the other team members in the room, and the opportunity to transfer knowledge among the different disciplines based on the project and the objectives, was the biggest improvement.

Statoil management and the different teams need to be interlinked with regard to communication and common understanding of the problem at hand. As far as the definition of the problem goes, it is in both the Statoil management's and the specific team's interests that they are both involved when it comes to defining and developing the target or the vision for the exact problem at hand. If both parties are involved they will have a common understanding of the area and the pitfalls of the objectives as well as having this understanding freshly in mind when the project arrives at the different decision gates in the Statoil system. The people in the Concurrent Design team work closely together and have expertise in different parts of the project process; thus it would be beneficial to both the timetable and the result to make use of the expertise already at hand.

Adequate Resources from Statoil

When Statoil forms Concurrent Design teams, it is crucial for the teams to be provided with adequate resources when needed. A team will not be able to perform to its highest standard according to its objectives if a significant amount of resources is not provided by the organization (Hackman, 1990; Smith et al., 1991).

Having the resources and the relevant disciplines available is crucial for the Concurrent Design team (Smith et al., 1991). If a team member was not available to work in a session or had to leave for another work task during a session, we noted that the productivity and progress of the project sank dramatically. On the other hand, we witnessed the efficiency and commitment by the team members were very high when all the members of the team were present and the work flow went according to the objectives for the session. For Statoil to be able to use the disciplines' engineers to perform engineering work, instead of joining meetings and giving status, might provide an important competitive advantage in the future.

Resources for a Concurrent Design team in Statoil are the various disciplines that are involved in a specific project as well as disciplines are given to participate (Smith et al., 1991). The team also needs an adequate work area as discussed true previously. Finally, the team must have access to the various computer applications needed to solve the tasks of the project. All these resources are provided by the Statoil organization in which the team operates and works. Putting all these aspects together, communication between the Statoil management team and the Concurrent Design team is of utmost importance if the team is going to produce a robust and innovative solution (Kirkman et al., 2004).

Reliable Information from Statoil Management

To provide creative and innovative solutions for Statoil, the Concurrent Design team needs access to applications and sources of information to be able to gather and make use of reliable information (Hackman, 1990). As mentioned above, the necessary resources, people who know the systems and are able to find and gather the data and information fast are important for the progress of the project. Statoil has many different databases and it can be frustrating and time consuming to find the relevant data you need to move the project forward.

The importance of reliable information is also relevant when it comes to the team's decision making. The decisions have to be made based on dependable, relevant and updated information and data. The Concurrent Design team also needs access to the information regarding Statoil's organization. The team has to publicize organizational changes and developments, which could be vital for the specific project the team is working on.

Being involved in the process of decision-making can give teams a better understanding of the overall problem, and knowing why decisions were made makes it more likely that people will be loyal to these decisions (Senge, 1990). Participants of the team can also learn from other fields and see why a solution that is not optimal in their particular field may be an optimal solution as a whole for Statoil.

Training in a Multi-Disciplinary Work Method

Participants in a Concurrent Design team also need to be trained for this way of working. Since the environment during the sessions sets certain demands on the experts, it might not be suitable for everybody. The experience from the Gudrun/ Sigrun pilot in Statoil was that people enjoy this way of working; they found it both fun and challenging to work in a new setting and to work closely with all the relevant disciplines of the project (Van der Vegt and Van der Vliert, 2000). When Statoil starts to use the Concurrent Design way of working throughout the organization, training can not be emphasized enough. The environment and the climate in a Concurrent Design room can be very hectic and sometimes loud with many discussions going on at the same time. We experienced very clearly the element of training when experts and "stand-ins" came to work with the Concurrent Design team. When a new participant joined the team during the project we experienced a decrease in the communication and information flow. The sharing of data sometimes stopped because of the inexperience of the new person working in a knowledge- and data–sharing environment (Kirkman et al., 2004).

Training in the work method has to be provided for all the participants before joining a team in Statoil. The question is whether some people are suited for this kind of work, or if everybody can gain from this way of working with proper training (Hackman, 1990). Either way, the point with the training is that everybody learns to see the value of working this way. For many people in Statoil it is not as natural to work in groups or teams as it is for many young people today. The participants must learn to view each other's ideas in a positive way, exploring their extent of possibilities and maybe selecting certain points from many ideas to work out a solution. This ensures a more constructive communication during the sessions, hence a better and faster solution through multi-disciplinary decision making (Øxnevad, 2000).

Regular Feedback: Both during and after the Project

Getting immediate feedback on their work and the feeling of being heard and appreciated can also be a motivational factor for the participants of a

Concurrent Design team at Statoil. Constructive feedback must be given in such a way that it opens up the possibilities of learning and understanding (Hackman, 1990). It should be objective, correct, and given at the right time. This requires good communication. It must not be moralizing and one must have a two-way communication.

Many people see it as a positive thing to be challenged, in this case on the field of their own competence to raise their level of competency and general knowledge through cooperation. For those who are more interested in doing their "own" thing and perhaps those in a narrow discipline challenges might be seen as threats. Hence, these two kinds of people need different means of motivation. For the latter group training becomes a key-factor by teaching them the value of others getting their results. The goal is to create a group of achievers in a high performance culture in the Statoil organization.

Another perspective: What is it that motivates people to be a part of a challenging work method like this in an organization such as Statoil? One of the problems today in Statoil is that many employees work towards their own set of goals and personal bonuses instead of working together towards a common goal in a group. In each session, all participants work together to achieve the same goals. Every participant will be an expert in his field (Øxnevad, 2000). Every participant will have a great deal of responsibility, be pushed to their limits, and explore new areas. However, they are experts in different fields and have to solve different sub-problems. Feeling ownership for their task is therefore an important motivator, just as feeling ownership for the whole project (Van der Vegt and Van der Vliert, 2000).

In addition, the learning process implicit in this work method can and should be a motivational factor (Van der Vegt and Bunderson, 2005). To exploit the Concurrent Design method fully, both formal and informal learning can be central elements in Statoil. Many of these challenges also exist in projects with less concurrency. Implementing concurrent work processes could highlight these challenges and be an inspiration and resource for other types of work as well. Hence, learning how to work this way and transferring that knowledge are good ways to educate the staff to be better group workers (Van der Vegt and Bunderson, 2005). The functionality of the method is that when experts have been deeply involved in the total process, much of the uncertainty that one finds in the organizations is diminished because one has witnessed the decisions, why the decisions were made, and so, at least to a greater extent than before, trust the decision-makers in the organization.

Technical Support when Needed

Every team needs some sort of assistance. Technical support from the organization is one way of making the communication between the Concurrent Design team and the rest of the organization better and more efficient. This technical support can range from information about whom to ask and where to look for help if a problem or situation should occur. Knowing your way around an organization can save the team valuable time, and, consequently, money. To enable the team to focus on their task and not on all the practical problems surrounding them is a more efficient and sensible use of your resources.

One of the benefits of the Concurrent Design method is the possibility of involving an expert at the work arena. If advice or information is needed, the Concurrent Design team can use their specific work field and their knowledge and expertise of the project to enhance the level even more by introducing the needed expert. It is also beneficial to use a Technical Assistant, or a secretary, during the sessions. When you operate in a concurrent environment, the discussions and the decisions are made rapidly. To have someone document these important decisions and other important discussions can be a very helpful (Øxnevad, 2000).

6. THE PITFALLS FOR IMPLEMENTING CONCURRENT DESIGN AT STATOIL

Throughout this case study, we observed firsthand the five tripwires which endanger implementation of a multi-disciplinary environment in an organization (Hackman, 1994). These are discussed in detail below.

Managers Call a Performing Unit a Team, but Really Manage it as a Set of Individuals

The Concurrent Design way of working is based on the contribution of every team member of the project. The Statoil management and especially the project managers have an important task when it comes to creating a culture and an environment for multi-disciplinary work. To manage this difficult challenge, the first part of the process is to identify and treat the team as a unit. The Concurrent Design team is a unit responsible for its deliveries and final results. To create a common understanding and a feeling of belonging is crucial to the members. Their feeling of commitment and team identification will, in the end, contribute to the standard of the result (Van der Vegt and Van der Vliert, 2000).

Concurrent Design contributes to a better understanding among the team members regarding the process and tasks they perform. The various disciplines get a better understanding of their own deliveries as well as of what the other disciplines contribute to the project. As the results of the questionnaire showed, the percentage of the aspect of understanding the whole value chain increased dramatically. According to Hackman (1994), a real team, as opposed to just a group of people working together, has three distinctive characteristics. The real team has a clear start and end point for the project and a stable number of team members. The second element of describing a real team is that it has a clear, common understanding of the goal and that everybody in a Concurrent Design team relies on the contribution and participation of every team member. The third and last element Hackman uses to describe a real team is the autonomy to manage, structure and, to some extent, plan their work and their processes within the Concurrent Design approach.

Imposing Too Much or Too Little Authority

The management of Statoil and the project manager have a set of goals and objectives they desire to achieve. The implementation of the Concurrent Design way of working is a tool to achieve some of these goals. To be able to make better decisions and faster solutions is a goal for every organization; the question is how they going to reach this set of objectives. When Statoil has decided to implement a multi-disciplinary work method, it creates some important implications for the organization as a whole (Hayes, 2002). Suddenly, Statoil has to balance the aspects of giving the team the autonomy and freedom to make its own decisions and the ability to reach their stated goals and objectives. On the other hand, Statoil has to coordinate and control the team in a way that these goals and objectives don't interfere with and go against the direction of the rest of the Statoil organization (Hackman, 1994). This dilemma may be a possible obstacle to implementing the Concurrent Design approach. The members of the team need to feel a certain level of autonomy to be able to do their best. The Concurrent Design team as a whole needs to experience that the Statoil management gives them the opportunity to make their own choices as long as the result is satisfying. On the other hand, giving the team total freedom and too much autonomy can result in bad decisions and an unstructured work process. This can, in the end, lead to the team not being able to meet its deliveries on time (Hayes, 2002).

Hackman (1994) believes the best way is to provide the team with a direction for their work. Statoil can achieve this by making very clear what they want the goal to be, and that this is under-

stood by the participants as well as by the project management. However, the team still needs the freedom and the creativity to decide within the team how they should go about meeting those goals and objectives.

The Tendency to Tear Down Organizational Structures

When Statoil implements a demanding work method such as the Concurrent Design, the rest of the organization will, to a greater or lesser extent, be implicated. The Concurrent Design team will have to position itself in the Statoil organization as well as vice versa. Statoil does not need to turn all their existing structures upside down when implementing the Concurrent Design work method in their organization. Statoil should keep its existing structures but give the Concurrent Design team enough resources and manpower to do the work according to plan and objectives in the most effective way (Hayes, 2002). This will create a better working environment and, in the end, a better result for the team and for the Statoil organization.

The most important elements are to compose the team according to the task, to have motivated and trained members of the team, and to have a clear norm of what is to be expected from the team. As long as these sets of norms and resources are at the team's disposal, the Concurrent Design team can be a well-functioning unit within the existing Statoil organizational structure.

Assuming Staff is Eager to Work in Teams and They Are Already Skilled at Doing so

The value of team training cannot be emphasized enough. However, Statoil should not assume or expect that everybody is skilled and ready to work in a multi-disciplinary manner. It takes training and practice to enable a Concurrent Design to function well. The team members have to be trained and skilled in how to communicate with the other disciplines (Øxnevad, 2000; Hayes, 2002). They must learn how to share, explain and especially visualize aspects and problems for the other participants of the team. There might be some resistance towards this way of structuring Statoil's work. The training and the preparation of the team members can be a very positive element in dealing with this resistance (Hackman, 1994).

The team members should also be trained in how to communicate and share their data. Often, when just starting a project, the various disciplines have to proceed with the project based on uncertain data. The experience of the pilot project at the Gudrun/Sigrun field was that engineers are not comfortable with the sharing of uncertain data. This is something that has to be learned and experienced through the training method. When working in parallel, the different disciplines have to get used to sharing (uncertain) data throughout the project process. It will create unnecessary stops and delays if some of the participants have not been trained or educated in the importance of data sharing between disciplines. If Statoil decides to establish permanent teams in the various divisions of its organization, the value of team training will be apparent. It will show what a team is capable of doing with regards to reducing time, and obviously costs, working in a multi-disciplinary way.

The same elements of training and preparing for working in the Concurrent Design way are important for the project managers in the different projects. The project manager needs to be able to make faster decisions, structure the project process and be totally involved in the various parts of the project. This requires a different approach and a different mindset for a project manager.

Skimping on Organizational Supports

The last, but probably the most important aspect, is the element of organizational support, or the lack thereof. If a team is going to produce and deliver

at its very best, the need for organizational support is crucial. The most effective team operates in safe and predictable surroundings. It creates a culture for the team and its environment that will increase the team's effectiveness and ability to produce better results in a shorter time.

Hackman (1994) describes the elements of reward systems, an educational system, an information system and material resources as enough for the team and its members to perform at its highest level. All these elements are discussed earlier in the chapter. Statoil cannot expect Concurrent Design teams to be able to fulfill their desired outcomes if they are not given the sufficient resources to do the job required. If some of the elements mentioned above are lacking, it will create frustration and a poor working environment, both in the Concurrent Design team and in the rest of the Statoil organization.

7. CONCLUSION

To be able to fully explore and make use of a demanding and challenging multi-disciplinary work method like Concurrent Design, Statoil needs to be prepared to make necessary resource commitments. It should pay attention to the psychology of the individuals and the teams. The structures of the organization will shift and so will the demands of the Statoil employee. Implementing this method will be a factor in increasing the empowerment of the employees as well as a contribution to making the Statoil organization well equipped to face the challenges ahead. Especially the increased international build-up, but also the work at the Norwegian continental shelf will benefit from working in a more efficiently and effectively. The impact of information technology, and the proper use of it, will make Statoil a leading company in its field.

If this work method is only implemented halfway, the organization will be damaged. We experienced, through our monitoring of the pilot project Gudrun/Sigrun, the enthusiasm and increased motivation of solving complicated tasks and handling difficult changes during the project. The overall efficiency, as well as the understanding of the full value chain of the project, were dramatically increased. But the best results came from the elements of the interdisciplinary communication and the fun factor. Working in a Concurrent Design way can, and will be, extremely challenging. The individual employee in the team represents their discipline of work. Each member has a huge responsibility to produce the best possible result. However, the employees of Statoil are extremely well educated and like being challenged. Thus, this is a way of working that gives them both the responsibility and the important fun factor of working side by side with experts in different areas, as well as the motivating factor of achieving a good result with the rest of the team.

REFERENCES

Andres, H. P. (2002). A comparison of face-to-face and virtual software development teams. *Team Performance Management: An International Journal*, *8*(1/2), 39–48. doi:10.1108/13527590210425077

Clampitt, P. G. (2005). *Communicating for managerial effectiveness* (3rd ed.). London, UK: Sage Publications.

Clark, K. B., & Fujimoto, T. (1990). The power of product integrity. *Harvard Business Review*, (n.d), 11.

Danilovic, M. (2006). Bring your suppliers into your projects - Managing the design of work packages in product development. *Journal of Purchasing and Supply Management*, *12*, 246–257. doi:10.1016/j.pursup.2006.10.009

Flin, R. H. (1997). Crew resource management for teams in the offshore oil industry. *Team Performance Management*, *3*(2), 121–129. doi:10.1108/13527599710190876

Ford, D. N., & Sterman, J. D. (2003). The liars club: Concealing rework in concurrent development. *Concurrent Engineering: Research and Applications*, *11*(3), 211–219. doi:10.1177/106329303038028

Hackman, J. R. (Ed.). (1990). *Groups that work (and those that don't): Conditions for effective teamwork*. San Francisco, CA: Jossey Bass.

Hackman, J. R. (1994). Tripwires in designing and leading workgroups. *Occupational Psychology*, *23*, 3–8.

Hayes, N. (2002). *Managing teams: A strategy for success*. Stamford, CT: Thomson Learning.

Henriquez, A., Fjaertoft, I., Johnsen, C., Yttredal, O., & Gabrielsen, T. (2007). Integrated operations: How Statoil is managing the challenge of change. *Management Focus*, (n.d), 25.

Hepsø, V. (2006). *When are we going to address organizational robustness and collaboration as something else than a residual factor?* Society of Petroleum Engineers.

Hepsø, V. (2009). Common information spaces in knowledge-intensive work: Representation and negotiation of meaning in computer-supported collaboration rooms. In Jemielniak, D., & Kociatkiewicz, J. (Eds.), *Handbook of research on knowledge-intensive organizations* (pp. 279–294). Hershey, PA: IGI Global. doi:10.4018/978-1-60566-176-6.ch017

Katzenbach, J. R., & Smith, D. K. (1993). *The wisdom of teams: Creating the high–performance organization*. Boston, MA: Harvard Business School Press.

Kirkman, B. L., Rosen, B., Tesluk, P. E., & Gibson, C. B. (2004). The impact of team empowerment on virtual performance: The moderating role of face-to-face interaction. *Academy of Management Journal*, *47*(2), 175–192. doi:10.2307/20159571

Kotter, J. P. (1996). *Leading change*. Boston, MA: Harvard Business School Press.

Koufteros, X., Vonderembse, M., & Doll, W. (2001). Concurrent engineering and its consequences. *Journal of Operations Management*, *19*, 97–115. doi:10.1016/S0272-6963(00)00048-6

Morton, S. C., Dainty, A. R. J., Burns, N. D., Brookes, N. J., & Backhouse, C. J. (2006). Managing relationships to improve performance: A case study in the global aerospace industry. *International Journal of Production Research*, *44*(16). doi:10.1080/00207540600577809

OLF. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf*. Oslo, Norway: Oljeindustriens Landsforening.

Øxnevad, K. I. (2000). *The NPDT – The next generation concurrent design approach*. EUSEC 2000, 2nd European Systems Engineering Conference, September 13th – 15th 2000, Munich, Germany.

Reinertsen, D. G., & Smith, P. G. (1991). *The strategist's role in shorthening product development. The Journal of Business Strategy*. July/August.

Senge, P. M. (1990). *The fifth discipline: Art and practice of the learning organization*. New York, NY: Doubleday.

Sharp, J. M., Belohoubek, P., Castka, P., & Bamber, C. J. (2001). Factors affecting successful implementation of high performance teams. *Team Performance Management*, *7*(7-8), 123–134.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. B. (2009). Integrated operations and leadership – How virtual cooperation influences leadership practice. In Martorell, S. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications*. London, UK: Taylor & Francis Group.

Smith, P. G., & Reinertsen, D. G. (1991). *Shortening the product development cycle. Research-Technology Management*. May/June.

Smith, R. P., & Eppinger, S. D. (1997). A predictive model of sequential iteration in engineering design. *Management Science*, *43*(8), 1104–1120. doi:10.1287/mnsc.43.8.1104

Statoil. (2005). *Annual report and accounts 2005*.

Statoil. (n.d.). *Home page* (in Norwegian). Retrieved from www.statoil.com/no

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *The Journal of Communication*, *42*(4), 73–93. doi:10.1111/j.1460-2466.1992.tb00812.x

Takeuchi, H., & Nonaka, I. (1986). The new product development game. *Harvard Business Review*, (n.d), 1.

The Norwegian Ministry of Petroleum and Energy. (2004). *St.meld. nr. 38* (2003-2004). Oslo, Norway: Om petroleumsvirksomheten.

Van der Vegt, G., & Bunderson, J. S. (2005). Learning and performance in multi-disciplinary teams: The importance of collective team identification. *Academy of Management Journal*, *48*(3), 532–547. doi:10.5465/AMJ.2005.17407918

Van der Vegt, G., & Van der Vliert, E. (2000). Team members' affective responses to patterns of intragroup interdependence and job complexity. *Journal of Management*, *26*(4), 633–655.

West, M. A., Hirst, G., Richter, A., & Shipton, H. (2004). Twelve steps to heaven: Successfully managing change through developing innovative teams. *European Journal of Work and Organizational Psychology*, *13*(2), 269–299. doi:10.1080/13594320444000092

Yin, R. K. (2002). *Case study research: Design and methods* (3rd ed., *Vol. 5*). Sage Applied Social Research Method Series.

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Chapter 11
Implementing Integrated Planning:
Organizational Enablers and Capabilities

Lone S. Ramstad
MARINTEK, Norway

Kristin Halvorsen
MARINTEK, Norway

Even A. Holte
MARINTEK, Norway

ABSTRACT

Transferring the IO principles to the planning domain has led to the development of the concept of Integrated Planning (IPL). The concept represents a holistic perspective on planning, emphasizing the interplay between planning horizons, between organizational units, and among cross-organizational partners. Based on findings from three case studies, the purpose of this chapter is to present how three companies in the oil & gas industry has approached integrated planning, illustrating some of the challenges they have experienced in the planning domain. With the findings as a starting point, the authors identified three enabling factors that need a particular focus when implementing IPL: ICT tools, roles & processes, and arenas for plan coordination. In addition, the authors argue that in order to succeed in implementing integrated planning practices, as well as continuously improving these, human and organizational capabilities need to be cultivated, and focus here on four salient features of an integrated planning practice: competence, commitment, collaboration, and continuous learning.

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INTRODUCTION

"Planning" is an imaginative and discursive practice (now underwritten by a wide range of more or less effective technologies) through which actors project what they might do and where they might go, as well as reflect on where they are in relation to where they imagined that they might be. (Suchman 2007:13)

With the prospect of increasing oil production, lowering operating costs, and prolonging field lifetimes, the petroleum industry is actively working to improve its ability to operate in an integrated and efficient manner across geographical, organizational, and professional boundaries. This effort is labelled Integrated Operations (IO) and it focuses on new technologies and enhanced work processes for improved decision making and safer, more efficient production.

As such, it can be said that IO is closely connected to Process, People, Technology and Organisation/ Governance (PPTO).and where the complex interaction among these four dimensions must be addressed for successful business transformation (Edwards T. & Mydland Ø.,(2010), Using the concept of a capability platform (as described by Henderson et. Al. Chapter N) emphasizes the synthesis of people, process, technology and governance, where no single dimension is more important than other. layers.)

Transferring the IO principles to the planning domain has lead to the development of the concept of Integrated Planning. Traditionally, the various domains of an asset, such as reservoir management, drilling, operations and maintenance, all have their separate activity and resource plans specific for their domain. These plans enable them to prepare for and follow up on their various operations and ensure that appropriate material and human resources are available for the specific tasks. Unfortunately, the different domains more often than not function as separate "silos" with little or ad hoc collaboration between them, and this way of planning and organizing of activities leads to an atomistic operational picture and inefficient resource management for the asset as a whole. The concept of Integrated Planning addresses these issues and lifts the goals of IO into the field of planning and deviation management. As such, Integrated Planning constitutes a holistic planning philosophy, and for some organizations perhaps a new organizational function, enabling the organization to manage operational plans across domains and handle continuous deviations in an optimal manner for the asset as a whole.

The IPL concept represents a real-time, holistic perspective on planning emphasizing:

- The interplay between different planning levels: strategic, tactical, and operational;
- The interplay between organizations, units, professions and groups that are involved in planning and execution;
- The critical interdependencies that have significant consequences for operational performance; and
- Feedback loops for continuous improvement of integrated planning processes.

The purpose of this chapter is to present findings from three case studies on integrated planning in the oil & gas industry and illustrate some of the challenges these companies experience in the planning domain. Based on the studies, we identify three enabling factors that prove to be significant for implementing IPL: ICT tools for aggregating and visualizing plan information; Roles and Processes for describing best practice; and Arenas for Plan Coordination. Designing and implementing such enablers, however, does not alone allow for a realization of the potentials inherent in IPL. Our studies illustrate clearly that IPL practices need to be fostered through human and organizational capabilities at the level of mindset and culture. We therefore discuss four salient features of organizational culture that need to be cultivated in order to continuously improve integrated planning practices: Competence, Commitment, Collaboration, and Continuous Learning.

PLANNING: THE ART OF MODEL BUILDING

The traditional idea of planning defines it as a method for making rational decisions (Banfield, 1959), essentially oriented towards optimization, achieving the best possible result within given constraints and with regard to the defined objectives. Stadler & Kilger (2008) call planning "the art of model building", as it is always necessary to abstract from reality the basis for establishing a plan. Planning is seen as support for decision-making, facilitating the identification of alternative future activities and the selection of the most appropriate activity considering all available factors. The challenge is to represent reality as simple as possible but as detailed as necessary, without ignoring any serious real-world constraints.

As it is impossible to describe a situation in every little detail, Suchman (2007) describes the plan as "*an orienting device whose usefulness turns on translation to action within an uncertain horizon of contingencies"* (p. 25). She claims that however well planned, purposeful actions are inevitably situated actions. Plans can be regarded as tools for coordination and communication creating the basis for a common understanding of the situation at hand. Also Gauthereau & Hollnagel (2005) see planning as a ''resource for action'' and the plan itself as a support for situated, ad-hoc action. Their definition differs from a more traditional understanding of planning as "detailed preparation of intended action, where each step is described in detail" (p.120). To see planning as a resource for action is an acknowledgement of the ubiquitous discrepancy between the predicted context and the actual context of execution. This perspective on planning shifts the focus to the continuous deviation or change management that is an integral part of operational planning.

Oil and gas production is in many ways a textbook example of the non-permanence of operational plans. The range of factors affecting the plan and forcing re-planning is long and unpredictable. Everything from internal events delaying execution to external factors such as the weather might have an impact on the operational plan (and consequently, potentially also on tactical and strategic plans). In order to be able to assess the consequences of such changes, not only for the activity in question but also for related activities, short term and long term, there is a need for a holistic plan picture and established integrated planning practices.

Integrated Planning: Horizontal and Vertical Integration of Plans

Depending on the time horizon, planning levels are used to classify planning tasks, often categorized as strategic, tactical, and operational planning levels. Stadler & Kilger (2008) differentiate between long-term planning (strategic decisions, over years), mid-term planning (regular operations, rough quantities, 6-24 months,), and short-term planning (detailed instructions for immediate execution and control, requiring the highest degree of detail and accuracy, a few days up to 3 months). Planning at short term level is an important factor for actual performance, but it is restricted by decisions made at higher levels of planning. Similarly, long term planning should adjust and coordinate with activities at lower planning levels. The concept of integrated planning is a strategy for making visible the interdependencies across planning levels, vertically, as well as within each planning level, horizontally.

The plan hierarchy (Figure 1) illustrates how planning occurs on different levels and with different time horizons. Although the companies studied define these intervals differently, the time horizons defined in the three companies do not, in principle, influence on their ability to integrate their planning practices. Some companies define the operational planning horizon to six weeks, whereas others look 3 months ahead at this level; some differentiate between work order plan with a two week horizon and operational plan that looks

Figure 1. Integrated planning: Horizontal and vertical integration



3 months ahead; some define the strategic level to be one year to field lifetime, whereas others will plan activities two to five years ahead at this level. However, what proves to be the core issue, is the company's ability to consciously and collaboratively define the most pragmatic definition of planning horizons, and from there work on closing the gaps between the vertical and horizontal boundaries in planning.

It is important to note that integrated planning does not only integrate activity plans vertically across planning levels, but it also integrates operational plans across domains at the operational level. This becomes particularly important considering the wide range of domains involved in operational planning of one single asset (drilling, operations, well services, logistics, maintenance, modifications, capital projects, personnel on board, personnel transport, and more). The various domain plans are not only produced by different organizational units with their own sets of goals and constraints, but very often several of these plans are produced by external organizations, vendors, and sub-vendors, providing services that are essential for the operation of the asset. Thus, IPL is highly concerned with bringing all these different plans together and seeing how they mutually affect each other. The IPL concept emphasizes that this integration must be facilitated at an early stage in the planning process, with an eye for the needs of other domains as well as how these needs are related to your own domain.

At the level of operational planning, each domain has their own planning circle, and Figure 2 illustrates its five main activities; input, coordination, approval, communication, and reporting. The planning circle is generic for the different planning levels and represents continuous activities within strategic, tactical, and operational planning.

Integrated Planning involves seeing each of these domain-specific planning circles and related plans in relation to one another and in relation to other domains in the asset to obtain coordination of activities and optimal utilization of resource.

The Value Potential in IPL

Integrated Planning affects the entire value chain of operations, and the coordination of activities therefore promises a more optimized resource allocation and improved efficiency. In turn, this contributes to reducing operational costs in all

Figure 2. The planning circle



domains involved, as well as avoiding conflicts through better coordination of plans. Coordinating for example heavy lifting activities with drilling and maintenance activities, allows not only for increased safety on board, but also for increased efficiency and safety as other domains can plan activities according to the limitations set by heavy lifting. In terms of safety, Prøsch (2011) discovered that the main triggering causes for accidents and incidents in lifting operations were connected to lack of planning. The total average number of lifts exceeding 200.000 a year on a single installation clearly shows that this is a significant area for improvement.

Similarly, well service activities require coordination with plans for personnel on board, transportation of people and equipment, other logistics operations, drilling operations, etc. IPL in this setting is an enabler for a early and optimal prioritization of activities allowing for the most productive sequence of activities and less frequent re-planning due to conflict.. This is particularly important on mature installations with the requirement of more frequent service intervals. For maintenance, having a better overview of the planned activities for a given period also represents a possibility for better exploiting resources for opportunity-based maintenance. For logistics in particular, IPL offers the prospect for improved allocation and distribution of resources across domains, thus enabling a better service at a lower cost. Finally, an improved holistic understanding of operations contributes to increasing the organization's agility and thus ability to exploiting opportunities in change and plan deviation

One of the companies in our study did some simple calculations as to the potential value inherent in improved and integrated planning, specifically related to planned production loss, start-up of new wells, and safety critical maintenance. These estimates indicate a significant value potential, approaching USD 30M for only a selected number of installations. Thus, improved coordination resulting in increased operational efficiency and reduced costs makes for a convincing business case.

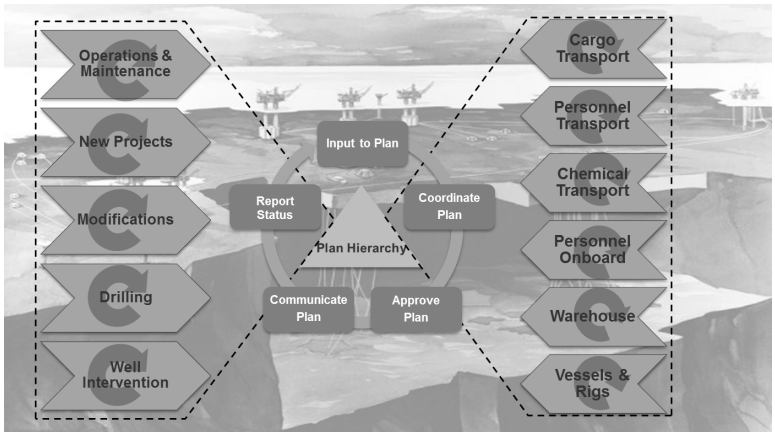
Challenges in Today's Planning in the Oil & Gas Industry

The oil and gas industry is characterized by a plethora of different actors, organizations and domains. On the Norwegian continental shelf, the operators typically outsource large parts of the operations, such as drilling, maintenance and modifications, as well as ISS (insulation, scaffolding, and surface treatment). This means that a range of vendors and sub-vendors are involved in the day-to-day operations of the offshore installation, and each of these participants engages in their own activity planning. This is visualized in Figure 3, illustrating planning circles in each domain feeding into the planning circle and plan hierarchy of the asset as a whole.

The lack of coordination across domains and organizations is a major challenge in today's planning, resulting in sub-optimal prioritization of activities and unnecessary down-time. One key aspect of this issue is the fact that each domain produces plans in different and very often incompatible planning tools. This complicates any effort to achieve a holistic picture of the operations, both on a short term and long term basis.

Planning of activities in this setting is also characterised by a high degree of uncertainty. A central challenge is the ability to manage the operational plan in the execution phase where deviations will occur. Limited resources, system failures, unscheduled maintenance, unpredictable weather, or even subsurface surprises causing interruptions to drilling, are some of the factors that make it difficult to complete work according to predefined plans. Often the consequences of such changes are not entirely clear, and while managing to postpone activities and adjust the plan accordingly, the companies are rarely able to exploit changes by mobilizing alternative activities where another had to be put on hold.

Figure 3. The complexity of integrated planning



In addition to uncertainties and the technical obstacles in today's planning situation, there are a number of human and organizational factors influencing the coordination of planned activities. Issues such as unclear roles and responsibilities, unfamiliar work processes, lack of information sharing, lack of commitment to plan processes, and lack of ownership are all well-known challenges for the operators. We will address both technical and organizational aspects in more detail below.

As mentioned, the findings presented in this chapter are results from case studies in three international oil & gas companies, all in the process of introducing IPL. The empirical studies have been based on field work, interviews, observations, and questionnaires. In two of the companies we have contributed in inquiries to identify challenges related to IPL and gap analysis of the current situation. The three companies have taken quite different approaches to IPL implementation, they are all at different stages regarding IPL, and they differ substantially in size and organizational form. Still there are some dimensions which seem to be focused in all three companies as significant when it comes to implementing and improving integrated planning practices. We will address them in the following.

IPL ENABLERS: DESIGNING INFRASTRUCTURE FOR IPL PRACTICES

According to Argyris (1992), organizational enablers describe important aspects of organizational design that contribute to developing specific organizational capabilities. General enablers are e.g. formal role and responsibility structures, information systems, incentives structures, procedures, and systems for organizational inquiry. Based on the three case studies, we have identified three main enablers that are particularly relevant for implementing and establishing integrated planning. These enablers are (1) ICT solutions, (2) Roles and Processes, and (3) Arenas for Plan Coordination. In contrast to human and organizational capabilities, which will be addressed in the next section, enablers are organizational aspect that can be designed and implemented. They can be seen to function as infrastructure that assists the organization in making the change towards new and integrated planning practices.

ICT Solutions

Groth (1999), view the basic contributions of information technology in organizations as categorized in three groups: (1) information storage,

(2) information processing and automation, and (3) electronic communication and comprehension of complex information. He further emphasize the coordinative power of the structured database (implicit coordination), and the remote access to structured data as important tools for organizing and coordinating work within and across organizational boundaries. All of these mentioned aspects of ICT are highly relevant for integrated planning, where a main challenge is sharing and coordinating real-time information across domains and organizational boundaries. This is further supported when revisiting the definition of IO, which presents the use of "ubiquitous real time data" as one of the key enablers of Integrated Operations (The IO center, 2011).

Within the context of ICT, empirical findings reveal that the following aspects are of particular relevance for implementation of IPL:

- Obtaining real time information, particularly for short-term planning
- Aggregation of data, information processing and sharing
- Visualization of plan interdependencies and consequences of plan changes
- Collaboration surfaces, facilitating communication and collaboration across organizational, professional, and geographical boundaries

For any planning activity to be successful the required level of information must be made readily available from all predefined information sources. The information provided must also be updated, providing a true representation of the actual situation. It must also be presented in such a way that it adds value to the process of establishing the overall plan. In theory, this sounds like a manageable challenge, but the complexity of operations in the oil & gas industry makes this a very demanding task. With operations characterized by a wide range of involved actors, (both across organizational domains and company boundaries), high risk operations, varying information integrity, and a constantly changing work environment, developing a truly integrated plan for any field or installation heavily depends on a combination of suitable and harmonized ICT tools.

Data from the three oil & gas companies showed that the planning process in general was particularly complicated due to the extensive use of different planning tools throughout the industry. The main problem, however, is not the variety of tools, but the lack of harmonization between them. The tools available rarely allow for automatic interchange of data. This significantly reduces the ability for efficient information exchange and is one of the main reasons for the necessity of manual transfer of data between systems and tools, and thus an important source of 'human error'. Planners in two of the companies highlighted this as a problem that jeopardizes the integrity of information, while also taking up unnecessary and valuable planning resources. This is an important challenge to overcome since information integrity and automatic transfer of real time data is an absolute necessity for the production of integrated plans that are trusted by all involved stakeholders.

All companies related to the need of harmonized ICT solutions that would enable availability and access to real time information from all involved stakeholders. Such a solution should also include the development of a shared collaborative surface, supporting easiness of communication and information exchange across organizational, professional and geographical boundaries. Recognizing that there is not one ICT solution that fits all planning activities across the industry, the information should nevertheless be made available to all involved actors in a harmonized format. Such a collaborative 'information platform' should contribute to remove any doubt regarding information integrity and significantly support the ease of information exchange. One of the companies in our study had overcome the problem of automatically sharing information between planning tools, but they experienced challenges with visualizing relationships between tasks and activities in the integrated plan. Since

the integrated plan was mainly text-based, it could not easily show dependencies between tasks or consequences of plan changes. In addition, not all operational domains were included in the integrated plan, as some were only represented with operational quotas, which resulted in only limited optimization of the offshore activities. In other words, the sharing of information is in itself not enough; integrated plans also need to present dependencies between activities and allow for testing out the consequences of different change scenarios.

Further, a collaborative surface would also be a valuable asset for the coordination of activities and operations across the different planning levels, such as the operation, tactical, and strategic levels. Only such a technological assistant will enable the establishment of integrated plans for all offshore operations within a given planning period. What more, this would also provide the integrated planners with the ability to improve the coordination of tasks and produce plans that have the commitment of the involved stakeholders. The latter also relates to the issue of trust, and how each domain actually believes that the planned activities are based on updated information. We will come back to the issue of trust when discussing Commitment as one of four key capabilities.

Due to the variety of information interfaces within and across organizations, coordination of information and information sharing becomes a complicated and difficult task. One company specifically voiced that this challenge would be significantly reduced if technology enabled highlighting of pertinent and critical information from each of the involved stakeholders, and in turn contributed to increased cross-domain interaction. This would make the work for the integrated planners more manageable and provide them with a better overview of how potential changes and critical aspects of domain specific operations could affect the execution of the integrated plan. In other words, the ICT tools need to 'make the invisible visible'.

Roles and Processes

Process design has been a key concept in management and organization studies for the last two decades, especially related to Business Process Reengineering (Hammer & Champy, 2001). The idea is to identify, simplify, restructure and describe processes, and to take advantage of the possibilities in modern information technology. This is based on the perception that improved efficiency and implementation of 'best practices' depends on harmonization of work processes.

All case companies studied emphasized the need for work process descriptions supporting implementation of integrated planning in practice. Thus, the new work processes that had been designed, or were in the process of being designed, emphasized improved integration and coordination through ICT and collaborative arenas across domains and organizations. Two of the companies had new or updated work processes in which both horizontal and vertical coordination were focused. This appears to have played an important role for implementing a new planning practice in general, but still the level of implementation of these work processes varied significantly across installations. Especially three issues related to lack of implementation seemed to have consequences for an integrated planning practice; (1) that the plan hierarchy was not completely implemented; (2) that foundation and prerequisites for the planning process were not well enough established; and (3) that roles and responsibilities were unclear and/or not understood/implemented.

Regarding (1), the use of harmonized ICT tools across planning levels, and consciousness about the value of a holistic understanding of planning, seemed to represent a challenge when it comes to vertical integration. In general, consequences of (1) were said to be: too much "unnecessary" ad-hoc planning, and absence of coordination of interdependent activities due to both lack of long term planning and identification of connected activities. Furthermore, ad-hoc planning contributes

to a high level of strain and lack of overview of total amount of activities, and should therefore be kept on a low level preserving the resilience of the organization.

Establishing common premises for decision making and prioritizing of resources, tasks and activities (2), is essential when several domains with their own objectives are involved in the same planning process. This is important for shared understanding of the planning process and for establishing common overall objectives. Defining operational pre-requisites (i.e. planning fundamentals), is an activity defined in work process descriptions which aim is to ensure that basic prerequisites are made explicit and known among all participants in the planning process. Our findings show that for many installations this was not an emphasized activity. Still, people involved in the planning process expressed that these were implicitly known or taken for granted; at least the most important constraints (e.g. HSE and limitations related to POB). A shared understanding of these conditions seemed to serve as efficient objectives and conditions for coordination and prioritization across domains.

In order to secure high quality in all planning activity, clear and unified definitions of roles and responsibilities are necessary (3). This includes the required information provided at the right time and at a specified quality level. However, roles and ownership *per se* is also of significant importance as it allows the owner of a plan to follow up the actual implementation, while also ensuring a clear understanding of relevant contact points (i.e. who to contact in case of change orders). Our studies showed that many actors involved in planning experienced that roles, responsibilities and formal ownership of the plans were not clear. The uncertainty could be related to whether the offshore unit or the land organization was the plan owner, and when the ownership was transformed from units onshore to offshore. This implied that the owner of the plans did not always follow up the work processes. Further, unclear roles and responsibilities contributed to reduced quality of data and input to plans, reducing the emphasis and follow-ups on special areas, and decision making was based on unclear responsibilities and uncertainty. In addition, key people functioned as bottlenecks in decision making processes. Being unaware of their significant role as decision makers, they were often not available when situations occurred. Despite these challenges, several actor groups experienced that the planning process was more systematic due to defined work descriptions, although indicating the potential for improvement of both development and implementation.

Some roles seem to be especially important for obtaining integrated planning; the planner, the task responsible and the leadership. Moreover, research showed that competence in planning seems to be lacking both among managers and task responsible. In general, operational planning as an organizational function and role did not seem to have high status in the companies. Yet, the increased awareness of this seemed to have spurred a shift towards systematically increasing the competence in planning, making its function and importance more visible in the organization. We will come back to the issue of Competence as a separate topic in the section on human and organizational capabilities for IPL.

Arenas for Coordination of Plans

The term "Post-bureaucratic organizations" (Heckscher and Donnellon 1994) has been coined to describe a long-term shift in corporate organizations, centered on the use of influence rather than power, on lateral, expertise-based coordination and teamwork rather than hierarchical, authority-based decision-making. These shifts in organizational orientation deeply affect the potentials in professional communication and collaboration. Consider the following example from the industry.

The planning of well maintenance involves decisions regarding the order in which wells should be serviced. The service is executed by

a roving crew that moves from one platform to the next according to the well service plan. The prioritization of these activities is dependent on a range of potentially conflicting objectives: the well service crew needs a travel schedule that is efficient and the work needs to be planned according to the man hours available; the use of night shifts must be in accordance to union regulations; the wells that have reached a safety critical state must be prioritized; the wells that forecast the highest level of production must be prioritized; service work needs to be coordinated with drilling plans as they occupy the same space; the necessary material and equipment must be available; the season and weather forecast must allow for the specific activities. These are just some of the objectives at stake in service planning. Looking now to Integrated Planning, the complexity of coordinating activities at a holistic level can be no less than overwhelming when all aspects and domains are taken into account. Prioritization of activities turns out to be a 'multi-objective decision problem'. Optimizing one objective might weaken another, and there is very often no optimal solution, simply a best possible one within the given and presently known constraints.

What becomes clear with this example is that the decision-making related to plan coordination consists of the competent assessment made by experienced personnel who represent the different domains involved, and who meet on a regular basis and discuss proactively the conflicts and potentials inherent in the given plan. According to the professionals in our study, only a "meeting of minds" can take into account all the various constraints and assign the appropriate "weight" to each issue. Planners in our study made it very clear that the introduction of automated decision tools would produce simplified presentations of the actual constraints at work. The consequence of this insight is clearly that establishing arenas for plan coordination are a key factor in integrated planning. The mere complexity of prioritization and coordination requires a forum in which plan data can be interpreted and communicated, where shared understanding of interdependencies can be developed, where coordination across domains can take place in a structured and facilitated way, and where collective learning and continuous improvement can be stimulated.

The three studies showed that all plants had established arenas for interaction related to operational plans, but only one of the companies had established arenas for coordinating tactical and strategic plans. This company had regular and facilitated meetings at all plan levels, also ones including contractors, with joint discussions and adjustment of plans within the time horizon set for each meeting. As an example, the tactical plan meeting (medium term) would allow Crane Operations to inform Drilling that in three months' time there would need to be a series of heavy lifting on platform X, over wells A, B, and C. Drilling could then find a time in their own plans that would be suitable to stop drilling in order to allow for the crane operations. The specific date for the work order was not necessarily decided in the meeting, but the information exchange had been facilitated by the time and place of the plan meeting. In addition, actors from other domains had been informed about this coming activity and would be aware of it in their own activity planning. This type of early coordination eases the unavoidable short term negotiations that arise as plan deviations occur, and allows for each domain to have a broader more holistic picture and preparedness for potential conflicts.

In general the frequencies of meetings related to plan coordination vary between companies and assets. Several plants practiced pre-meetings to coordinate activities and used the plan meeting as an arena for final clarifications and decisions. At some plants decision-making were not done in the official plan meetings, but rather in subsequent meetings (which was not in compliance with the company work process model). At some plants an explicit agenda was lacking or the agenda seemed to be unclear, and meeting management

was loosely structured without action logs or summaries of decisions made. These meetings were generally poorly attended and considered less important arenas. The observations showed that participants came unprepared to the meetings, which led to repeated discussion of issues already clarified or that should have been clarified in advance. Participants would frequently show little interest in discussions that were not explicitly related to their own domain.

There are two central challenges when it comes to establishing arenas for plan coordination. These are related to the inclusion of the drilling domain and of contractors. Generally, drilling plans provide the premises on which other plans are made, but without there being any actual pro-active coordination of these plans. This is a well-known fact in the industry. Drilling is a key activity, holding the promise of future revenue as well as representing significant cost if activities are stopped or postponed. With this unique organizational position, involving drilling in arenas for plan coordination has proven to be a challenge for all three companies. Drilling is usually allowed a defined quota of beds on the platform and therefore is less involved in the fight for prioritization as the other domains. Similarly, contractors represent a large number of activities on board. Only one of the companies had established a formal arena for plan coordination with contractors at the level of integrated planning. The other companies acknowledged the need for this kind of forum and planned on involving contractors more closely in the future.

In the companies and assets where the plan meetings were well established and attended, these were characterized by a defined form and agenda, a predictable structure, defined outputs, and with a focus on time and relevance for all participants. The focus was on overall coordination, not details of specific domains. Well facilitated meetings provided valuable and efficient coordination, and stimulated continued participation in the meetings. One of the companies had included in their work process models a symbol that defined when collaboration and coordination needed to take place. The signaling of a need for collaboration tells the professionals that this is a crucial point in the work flow and that coordination with others is needed. At one of the plants the manager expressed that participating in the meetings were the only way to promote your interests and argue for /negotiate prioritization of activities and resources. As the arenas for coordination had been established and proven valuable, the various domains over time became more involved and active in the plan meetings.

IPL CAPABILITIES: CULTIVATING IPL PRACTICES

While IPL enablers will allow the organization a significant step in the direction of integrated planning practices, they will not alone provide the necessary momentum for meaningful and sustained change. Whereas organizational enablers can be designed and implemented, what we here call IPL capabilities are aspects of planning that cannot be regulated or determined. The four C's described below are human and organizational capabilities that will ensure the sustained implementation and improvement of IPL practices. These are features of organizational culture that need to be cultivated and stimulated through continuous attention and focused leadership, and hence contribute to establishing a culture that builds and maintains scalable and sustainable practices (see Chapter 1 in this book).

Competence

The first capability that seems to stand out as central in IPL is competence, emphasizing knowledge and expertizes which seem to be crucial for realizing the potential in IPL. Competence is here defined as to know how to do certain things (Ryle, G., 1949) including both knowledge and skills

to perform work tasks in practice. *S*ome types of competencies seem to be crucial when it comes to IPL: (1) a holistic and shared understanding of IPL among the involved parties (including processes, roles and dependencies in the plan), (2) competence in utilizing ICT tools sufficiently, and (3) competence in cross-domain collaboration and communication. In addition, competence in terms of learning and change has been emphasized by the industry professionals when it comes to implementing IPL.

Designed IPL work processes involve professionals and decision-makers in all domains and at different levels. Each of these participants needs to understand the principles and objectives behind IPL, the designed planning processes, and the roles defining expectations and responsibilities. Especially important is the need for being able to see one's own role and responsibilities as it relates to those of others in the planning process. Our findings show that lack of understanding of the holistic processes negatively affect the implementation of the designed planning processes, resulting in too much ad-hoc planning, inefficient information sharing, and dependencies between activities not being taken care of.

Being able to take advantage of the information and tools available in the ICT platform enable participants to take measures themselves to acquire information and coordinate with others. However, this requires all involved participants to have necessary knowledge and skills about available ICT tools. It is also crucial that they understand the potential of such tools and are aware of the value of continuously updating and sharing data and information with others.

Competence in cross-domain collaboration and participation in arenas for coordination is essential in IPL. Establishing new and well-defined arenas is only valuable when there are professionals capable of making the arenas effective and meaningful. Cross-disciplinary collaboration, often in a virtual environment, requires communicative skills that are not necessarily part of the professionals' training. Facilitating such arenas also require skills that too many are new and unexplored. Especially this seems to be an important part of the planner role that is a key role in IPL.

Defining necessary competence and expectations related to key roles in IPL (the planner, leaders and task responsible) seems to be an important issue, especially the planner role. Repeatedly in our data, the planner was emphasized as a critical component in the planning process, and three main areas were identified in terms of roles and desired competence, namely; the planner as facilitator, general planning competence (including knowledge to ICT tools), and operational experience. Moreover, the role as facilitator seemed not to be sufficiently supported by targeted competence development (e.g. planners' training programs), even if this should be a core competence for facilitating coordination and communication across domains. Further, it appears to be a common understanding that experience from offshore operations were highly desirable and viewed upon as an important competence for any planner. Not only does it allow him/her to easier see dependencies between activities and make more realistic and executable plans, but also for avoiding too much detail-specific planning.

Moreover, we experienced different levels of IPL implementation, and one main reason for this variance seemed to be the leaders and their competence in planning and integrated planning in general. Such competence includes knowledge about the described work processes and how to implement them in the local context, as well as engagement in and ownership to the process itself. This is supported by the installations showing high level of implementation, were the leaders have comprehensive knowledge of the work processes while also proving the willingness to implement them in the daily work. This clearly indicates that successful implementation of IPL practice is highly dependent on involvement and participation of the users, and above all, commitment from the leaders.

Commitment

Commitment is defined as "the trait of sincere and steadfast fixity of purpose" or "the act of binding yourself (intellectually or emotionally) to a course of action" (Webster's Online Dictionary). Organizational commitment has been conceptualized largely as a psychological state related to the individual's sense of belonging or attachment to the organization (Meyer and Allen 1991), but in this setting we will understand the concept as it relates to organizational practices and individual as well as collective orientations towards defined roles and processes. In other words, commitment, less to the organization *per se*, but more to the overall IPL objectives and the processes defined in order to reach these.

Organizational literature focusses on commitment and trust as key dimensions in organisational change processes and in design of technological information systems. Participation and active involvement in the development and design processes by all affected actors are required for obtaining this (Morgan, 1986). The managers and planners in our data, who actively participated in the IPL development process, expressed the highest degree of satisfaction with the IPL concept. But in all three cases there were groups that expressed lack of commitment and who were unmotivated to follow up plans. Clearly there was a lack of trust in the system or the value of it. In one of the cases, the ICT tools for integrated planning had been developed over several years, but not all actor-groups were involved in the development and design process. Consequently, some of the planners felt that they were not seen as important contributors to the concept itself, and therefore did not acknowledge their key role during implementation and follow-up of the IPL concept.

Once the ICT tools are in place and implemented, the level of commitment achieved will show in the quality of the data that is entered into the planning tools. Ensuring updated input on plan status is a precondition for producing a reliable operational picture for the entire asset. This requires a mindset in the organization that understands the value of the holistic picture as well as the consequences of incomplete data. Part of this mindset is also commitment to established work processes and compliance with the roles and responsibilities defined in steering documentation. Each professional needs to remain accountable in terms of their own organizational role, and also respecting the roles and responsibilities of others. The joint commitment to an overall goal is an essential part of integrated planning practices.

The lack of commitment, found in some parts of our data, can be interpreted as resistance against an increased centralisation of decision making and reduced autonomy in the individual domains of the asset. Our case studies show that there is a balance to be found between centralized decisions regarding prioritization and decentralized empowerment giving room for professional expertise and experience to guide operational decisions. The changing nature of offshore operations requires that professionals are able to act not only according to procedures and plans, but also according to the demands of the given situation. The decisions and prioritization made at the level of the offshore crew are important elements of optimization within the boundaries of the integrated plan.

Also when it comes to collaboration arenas, commitment is central. All necessary roles need to commit to participating in these forums, as a minimum requirement. In order to transform such forums into valuable arenas for coordination, however, participants need to arrive prepared and ready to engage actively in discussions regarding plan prioritizations. As mentioned earlier, this was not always the case in our data and it proved to undermine the function of the plan meeting. This is not simply a matter of the individual's attitude to planning, but is also an issue of organizational culture for joint problem-solving and joint ambition towards a common goal.

Finally, it is important to note that by commitment we do not imply the unquestioned following of procedures and rules. A primary strength of knowledge workers is precisely the ability to use their competence and experience to remain skeptical and question current practices and decisions. However, the IPL concept implies a centralization of decision-making rights and requires that the professionals at different organizational levels understand the value of such a change and experience it as meaningful related to their own work.

Collaboration

Collaboration is in many ways the heart of integration. The constructive combination of people and ICT tools allows for improved exchange of real-time information, and thus enhanced coordination of plans and resource utilization. According to Camarinha-Matos.et.al, (2006), collaboration is a process in which different entities share information, resources and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal. Thus, since operations in the oil and gas industry involve numerous participants, roles and services, collaboration becomes a key asset for achieving efficient operations (i.e. the common goal).

However, for collaboration to prosper and become an established fundament for operations in the oil & gas industry, having access to a set of harmonised set of ICT tools are absolutely essential. With access to such integrated information systems, updated and real-time information can easily be exchanged among relevant actors during all planning stages. Equally important is that the level of information detail can be better adapted to the individual needs of the recipient. This aspect becomes even more critical when establishing integrated plans, since collaboration very often goes across organizational and geographical boundaries.

To a large extent, this is lacking among the studied companies, and seems to be a key obstacle that must be overcome if one is to succeed with establishing IPL practice. The findings show that due to lack of interoperability among planning tools (caused by the application of a large variety of planning tools), both the exchange and availability of real-time data between domains and across organisations were to a large extent hindered. The result was that planning activities could be based on unreliable information, in turn jeopardizing the credibility of the plan itself. Consequently, in some companies integrated planning was regarded as a 'must-do' as it was defined in the work processes, which in turn had a negative effect on collaboration across disciplines and organisations. As such, this is a good example of a mismatch between what is specified in the work processes and the availability of tools for improving planning practice.

Although collaborative surfaces can be facilitated through shared and harmonized ICT systems, they can only be established if visualised and defined in the established work processes. The different roles must also be assigned with a collaborative responsibility. This includes clear and precise descriptions of relevant collaborative surfaces, including the specific level of information need for the different actors (i.e. the right information to the right people at the right level of detail). Arenas for allowing this to prosper are therefore essential for establishing a fruitful collaborative environment.

Moreover, collaboration requires arenas and opportunities, but also willingeness and ability in members of the organisation. Willingness is created through motivating but also through experiencing the value of collaborating, seeing for oneself that there is value in participating. Ability per se can be fostered through training and experience, but also through forums for exchange of knowledge and experience. Thus, open communication, trust, dialogue and positive conflict

negotiations are important for creating a constructive collaboration climate, since interaction across boundaries is especially challenging when it comes to establishing good collaboration climate.

Continuous Learning

Continuously learning is here understood as organizational learning which is regarded a fundamental requirement for all organizational changes and sustained existence. Thus, the success of implementing IPL is dependent on the organization's capability to secure organizational learning and do appropriate changes in planning practices. Building on organizational theories we argue that organizational learning is processes involving social learning and participation (Brown and Duguid, 1991, Wenger 2000, Nicholini et.al 2003), collective reflections, inquiries and experience sharing (Argyris.C and Schön, D.A.1978, Elkjær, 200).

According to the practice based learning theories (Wenger 2000, Nicholini et.al 2003), learning has to be connected to practice and the people involved in planning if the ambition is to change the way people and organizations work. Our findings shows that broad participation and involvement from all domains in collective learning processes at the installations were crucial when it comes to implementation of IPL. The designed common "best practice" for planning as described in the steering documentation required interpretation and transformation, taking the local context into consideration. Some of the installations used the described work processes actively as tools for: discussions about how to obtain IPL, reflections on planning practices and experience sharing. In this perspective the described work processes can be considered as *boundary objects* (Wenger, 1998) in a collective learning process functioning as a common reference/picture for communication, reflections and shared understanding across boundaries.

Our findings showed that these kind of collective learning processes were initiated and facilitated by leaders with strong commitment to the designed work processes. Further, that lack of leader commitment and engagement in implementation of IPL were the main reasons for the low level of implementation registered at several installations. As coordination and planning of operational activities are time critical activities, leaders in general consider it challenging to spend time and resources on processes for implementation of new roles and work processes. Experience sharing and evaluation of the planning processes were not an integrated part of the planning practices at all installations and seem to be missing as a natural part of a learning culture.

Continuously learning is also a key capability when it comes to design and implementation of plan coordination arenas. In one of the companies, experience based learning was a key strategy for testing and designing coordination arenas as a continuous learning process. Our findings show that the plan coordination arenas function as efficient learning arenas when they allow for some degree of reflections on the IPL practice and experience sharing. In this sense they are powerful arenas for learning by virtue of being directly connected to planning and what people actually do in planning work. Still, to function as arenas for learning some key conditions needs to be in place: open communication, actively participation and involvement by all disciplines. E.g. stronger involvement of well and drilling disciplines at the plan coordination arenas has contributed to increase information and knowledge sharing in the planning and decision processes. The willingness of collaboration seems to be a critical issue due to lack of shared understanding and common goals. Developing a holistic understanding of the planning domain is regarded an important measure in order to establish a collective mindset supporting collaboration and learning.

Figure 4 shows the four capabilities related to the IPL enablers where continuous learning is a capability required to ensure transformation and implementation of the enablers into an integrated planning practice. At the same time it has an enforcing effect on competence, commitment and collaboration as these are dynamic capabilities which are amplified through continuously learning.

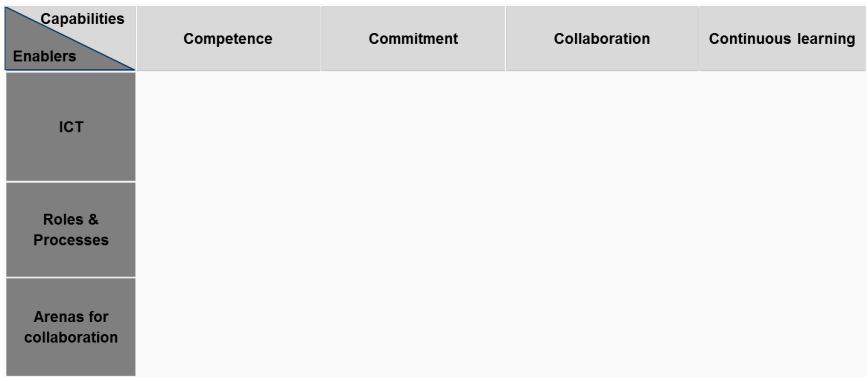
RECOMMENDATIONS

Implementing IPL will depend on designing key organizational enablers that will allow the organization to take the step towards a more holistic perspective on planning. Harmonized ICT tools for integrated planning across domains and organizations need to be in place for the organization to be able to orient to a shared operational picture. Work processes and roles need to be clearly described and understood in order for employees and managers to jointly strive towards an optimal coordination of activities across the domains. And finally, arenas for plan coordination need to be in place allowing the professionals to come together and jointly discuss and adjust activities on short, medium, and long term time horizons.

It is important to note that the design and implementation of enabling factors need to be supported by a planning culture that fosters competence, commitment, collaboration and continuous learning. The latter serves a particular purpose in securing the organization's ability to incorporate operational experiences into the planning domain, while also having an enforcing effect on competence, commitment, and collaboration. Devoting time and resources to improve performance provides the companies with a better understanding of operations and how to make them more efficient. In turn this supports the development of closer relationships between domains and across organizations, while also focusing on how employees work together. What we have called IPL capabilities are human and organizational features that need to be stimulated and motivated through continuous focus and leadership. An IPL practice involves breaking down boundaries and establishing a renewed and focused sense of "we", across organizational domains and including organizational partners and contractors.

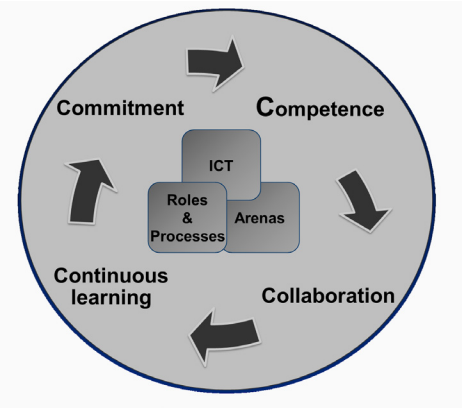
Management plays a key role in both implementing the enabling conditions and fostering a strong integrated culture. As the individual company will have different areas that need focus, and will have reached different levels of maturity in terms of implementing IPL, the first step will be to assess the particular challenges of the organization and decide on a road map for the continued development of IPL. Screening tools have been developed and methods for analysis (e.g. gap

Figure 4. IPL enablers and capabilities



analysis etc.) for these kinds of processes. What we suggest is a focus on the three key enablers and an emphasis on the continued attention to the IPL capabilities of competence, commitment, collaboration, and continuous learning (Figure 5).

Figure 5. The IPL model: Enablers and capabilities



FUTURE RESEARCH DIRECTIONS

The need to develop technological solutions enabling operators to obtain a more holistic view of their plans and activities has become very clear throughout the studies. There is an increasing demand to develop information systems providing the users with the ability to collect, distribute, and exchange information between professions and across organizations. Thus, developing a common collaborative surface capable of showing critical dependencies between tasks and operations will become imperative, along with suitable user interfaces for such systems. IFE in Halden is currently developing a prototype enabling scenario simulation for operational planning, where a touch-screen user interface allows the users to explore consequences of plan changes (Veland & Andresen, 2011). Linking such a tool with other forms of decision support will be important for reaching faster and better decisions (e.g. optimization tools).Another possible track to follow is to explore how the introduction of a harmonized information 'cloud' (i.e. internet-based information server), may affect IPL practice. Research within this topic is already ongoing within the transport sector, were the 'cloud' is meant to be the single point of contact for all involved actors, and thus the main source and enabler of automatic information exchange (e.g. Finest, 2011) The highly dynamic nature of the industry, and the large amount of data and information exchanged between actors, calls for more concrete knowledge on how to tailor information packages according to different actors' specific needs. In other words, there is a need for a deeper understanding of the level of detail the different actors need in terms of information, and also when they need it and what information they are expected to provide. Still it is an interesting question to which level of detail it is optimal to plan and how much work capacity that should be available for changes and unexpected events. Unquestionably, the planner holds a key role in IPL, but the current status and authority that comes with the role often makes it a difficult position to hold. More research should be directed towards exploring this role for better understanding the right level of responsibility and authority, as well as how this role can be aligned with other roles, within and across organizational boundaries. In this respect, understanding the planner as a facilitator for holistic plan coordination will also be subject for future research activities.

Establishing arenas for plan coordination will uncover the need for exploring the communicative competence required for collaborating effectively in these kinds of forums. The plurality of participants and information sources, as well as the multimodal format, make these arenas complex communicative situations for which many professionals are not prepared. The demands this puts on the professionals, what communicative skills, training, and support is required, are aspects that need to be further explored.

Whereas Generation I of Integrated Operations has focused on company-internal integration, Generation II will involve a greater focus on the integration between operator and vendor, as well as an increasing involvement of sub-contractors. The industry is increasingly moving into a Generation II focus, and IPL is seen as a key area where this integration process can take place. Arriving at a joint operational picture across organizations will allow for improved coordination of activities at an early stage, resulting in reduced conflict and improved resource utilization.

CONCLUSION

The concept of Integrated Planning brings the principles of Integrated Operations into the domain of planning, focusing on integrating plans vertically across planning horizons as well as horizontally across organizational domains. Understanding the interplay between activities and resources, including their interdependencies and constraints, requires a holistic operational picture that is shared and valued by the actors involved. The value potential in such an effort lies in improved coordination and prioritization of activities, resulting in better resource allocation, strengthened cost control and reduced conflict. In addition, IPL opens up for exploiting opportunities inherent in change and plan deviation.

Through our empirical studies with three oil and gas operators, three key enablers for implementing an IPL practice have been identified. These are aspects of organizational design that can be decided and implemented based on the individual organization's maturity assessment. Harmonized ICT tools, renewed process and role descriptions, as well as established arenas for plan coordination will all bring the organization closer to a truly integrated planning practice.

However, an organization's ability to achieve efficient and integrated planning practices rests on its ability to work with human and organizational capabilities of a much more intangible nature. Our four identified features of organizational culture are therefore necessary for bringing out the potentials inherent in the defined organizational enablers. An integrated planning culture understands the importance of planning and it is robust and proactive, with the ability to "foresee" and take advantage of change and unplanned variance. Also, it has a high degree of structure and predictability, understanding its roles and crucial interdependencies.

The empirical findings clearly show that the status of IPL is moving from being addressed as a concept towards a new standard of work. Work processes, roles, collaborative arenas, and ICT solutions are continuously being developed for improved planning practice, and thus more efficient operations and resource utilization. It is therefore likely that the pursuit for improved IPL practice will hold a prominent position for the industry and in research arenas for years to come.

REFERENCES

Argyris, C., & Schön, D. A. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison – Wesley.

Banfield, E. C. (1959). Ends and means in planning. *International Social Science Journal*, *11*(3), 361–368.

Camarinha-Matos, L. M., Afsarmanesh, H., Ferrada, F., Pereira-Klen, A., & Ermilova, E. (2006). *Rough reference model for collaborative networks*. D52.2, ECOLEAD project.

Dosi, G., & Marengo, L. (1994). Toward a theory of organizational competences. In England, R. W. (Ed.), *Evolutionary concepts in contemporary economics*. Michigan University Press.

Edwards, T., & Mydland, Ø. (2010). *The art of intelligent energy (iE) - Insights and lessons learned from the application of iE.* Paper presented at the SPE Intelligent Energy Conference, Utrecht, NL.

Elkjær, B. (2004). Organizational learning: 'The third way'. *Management Learning*, *35*(4), 419–434. doi:10.1177/1350507604048271

Finest. (2011). *Future internet enabled optimization of transport and logistics business networks.* Retrieved from http://www.finest-ppp.eu/

Gauthereau, V., & Hollnagel, E. (2005). Planning, control, and adaptation: A case study. *European Management Journal*, *23*(1), 118–131. doi:10.1016/j.emj.2004.12.016

Groth, L. (1999). *Future organizational design: The scope for the IT-based enterprise*. Chichester, UK: John Wiley & Sons.

Hammer, M., & Champy, J. (2001). *Reengineering the corporation: A manifesto for business revolution*. New York, NY: HarperCollins.

Hecksher, C., Donnellon, A., & Appelgate, L. M. (Eds.). (1994). *The post-bureaucratic organization: New perspectives on organizational change*. Los Angeles, CA: Sage.

Lilleng, T., & Sagatun, S. I. (2010). *Integrated operations methodology and value proposition.* Paper presented at the SPE Intelligent Energy, Utrecht, NL.

Meyer, J. P., & Allen, N. J. (1991). A three-component conceptualization of organizational commitment: Some methodological considerations. *Human Resource Management Review*, *1*, 61–89. doi:10.1016/1053-4822(91)90011-Z

Morgan, G. (1986). *Images of organization*. Sage.

Nicolini, D., Gherardi, S., & Yanow, D. (2003). *Knowing in organizations: A practice-based approach*. USA: M.A.Sharpe.

OLF – Oljeindustriens Landsforening. (2007). *Integrated work processes: Future work processes on the Norwegian Continental Shelf*. Rapport November.

Prøsch, K. (2010). *Forbedring i sikkerhet i kran og løft operasjoner basert på bedre samhandling i logistikkprosessen for brønn og boring*. Master Thesis in Marine Systems, NTNU.

Ryle, G. (1949). *The concept of mind*. London, UK: Hutchinson.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. S. (2009). Integrated operations and leadership – How virtual cooperation influences leadership practice. In Martorell, S. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications* (pp. 821–828). London, UK: Taylor & Francis Group.

Stadtler, H., & Kilger, C. (Eds.). (2008). *Supply chain management and advanced planning*. Berlin, Germany: Springer-Verlag. doi:10.1007/978-3-540-74512-9

Suchman, L. A. (2007). *Human-machine reconfigurations. Plans and situated actions*. Cambridge, UK: Cambridge University Press.

The Centre for Integrated Operations in the Oil and Gas Industry. (2011). *Website*. Retrieved August 25, 2011, from http://www.ntnu.edu/iocenter

Veland, Ø., & Andresen, G. (2011). *Scenario composer. A collaborative planning tool for offshore petroleum operations*. Poster at the 7th International Conference on Integrated Operations in the Petroleum Industry, Trondheim, Norway September 13-14.

Vidar, H., et al. (2010). *Next steps to a framework for global collaboration to drive business performance.* Paper presented at the SPE Intelligent Energy, Utrecht, NL.

Webster's Online Dictionary. (2011). *Commitment*. Retrieved July 2. 2011 from http://www.websters-online-dictionary.org/definitions/Commitment

Wenger, E. (1998). *Community of practice: Learning, meaning, and identity*. Cambridge, MA: Cambridge University Press.

Wenger, E. (2000). Communities of practice and social learning systems. *Organization*, *7*, 225–246. doi:10.1177/135050840072002

Williams, P. (2006). *How collaborative environments influence culture & behaviour*. Presented at the SPE Intelligent Energy, Amsterdam

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Chapter 12
Promoting Onshore Planners' Ability to Address Offshore Safety Hazards

Ann Britt Skjerve
Institute for Energy Technology, Norway

Grete Rindahl
Institute for Energy Technology, Norway

Sizarta Sarshar
Institute for Energy Technology, Norway

Alf Ove Braseth
Institute for Energy Technology, Norway

ABSTRACT

With new generations of Integrated Operation, the number of offshore staff may be reduced and more tasks allocated to onshore staff. As a consequence, onshore planners may increasingly be required to address safety hazards when planning for task performance offshore. The chapter addresses the question of how onshore planners' ability to address offshore safety hazards during planning of maintenance and modification tasks can be promoted by use of visualization technology. The study was performed using the IO Maintenance and Modification Planner. Eight domain experts participated in the study, performing in all thirteen scenarios of 30-40 minutes duration. Data was obtained from system logs, participant interviews, questionnaires, and expert judgments. The outcome of the study suggested that visualisation of planned jobs on a geographical representation of the decks at the installation, in combination with indications of associated safety hazards, served to promote onshore planners ability to address offshore safety hazards.

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INTRODUCTION

Performance of maintenance and modification activities is of key importance for ensuring commercial success in the petroleum industry. The overall objective of maintenance is to "...increase the profitability of the operation and optimize the total life cycle cost without compromising safety or environmental issues" (Khan and Haddara, 2003, p. 561). The overall objective of modifications is likewise to increase the profitability of the operation. Modifications typically aim at providing an installation with increased capacity, e.g., to perform tasks faster and/or with new functionality.

At the Norwegian Continental Shelf (NCS), petroleum companies gradually introduce the operational concept Integrated Operation (IO). IO has been defined as "… the integration of people, processes, and technology to make and execute better decisions quicker"(Lilleng and Sagatun, 2010, p. 2). It implies that real-time data from offshore installations are brought onshore, and thus builds premises for development of new integrated work processes (Holst and Nystad, 2007; OLF, 2005; 2008). IO may look very different at different installations. Edwards et al. (2010) report that they generally recognize IO on an installation based on the introduction of three changes:

1. A move to a real time or near real time way of working
2. The connection of one or more remote sites or teams to work together
3. A move to more multidiscipline way of working.

The introduction of IO implies that the traditional ways of working is substituted by IO ways of working (Ringstad and Andersen, 2006; 2007). IO tends to imply that tasks are moved from offshore to onshore. The tasks moved from offshore are often associated with administration and planning. In many companies, the introduction of IO implies the establishment of a decision-making land organisation, collaborating with an executing offshore organisation (Drøivoldsmo et al., 2007). IO, further, tends to involve increased outsourcing of work to contractors and other third parties, as well as closer integration between operator and contractor tasks (Skjerve and Rindahl, 2010). In future generations of IO, the number of tasks performed onshore is likely to further increase due to technology advances and increased maturity of IO organisations (St. Meld. Nr. 38). This will probably lead to fewer positions offshore. Means for establishing increased onshore understanding of offshore situations and risks will thus be of key importance.

At petroleum installations where IO presently is introduced, detailed planning of maintenance and medication activities are typically initiated by onshore planners, engaged in creating plans covering maintenance activities that should be carried out during a particular 2 week period, i.e., 14-day plan. While preparing 14-day plans, the onshore planners mainly focus on ensuring that the resources required are available. Today, the potential safety hazards associated with a plan are typically first addressed by the offshore staff 24-hours prior to job execution. The term hazard - in the following also referred to as a safety hazard – is defined as "… a situation in which there is actual or potential danger to people or the environment" (Storey, 1996, p. 33). When onshore staff detects hazards, they will re-prioritize the planned jobs, and send a subset of the jobs back onshore for re-planning. If, over time, many jobs have to be re-planned in order to meet safety requirements, this may result in a significant backlog, i.e., jobs waiting to be performed. If jobs remain in the backlog too long, new safety hazards may arise, e.g., because needed equipment stops functioning. An organisation, whose planners are able to address safety hazards also in the earlier stages of the planning process, would improve its capability both for safe maintenance and for creating plans that are realistic to meet (attainable plans), and through fewer jobs being sent back for re-planning, reduced backlog.

The purpose of the present study was to investigate how visualisation technology might facilitate onshore planners' ability to identify offshore safety hazards during the process of developing 14-days plans. The concept visualization technology is used as a reference to technology that visualizes data or knowledge on the user interface. Focus is on planning of maintenance activities, as well as minor modifications (see section "Background").

The study was performed as an integrated part of a formal usability study of a software tool under development called the IO Maintenance and modification Planner (IO-MAP) (Skjerve et al., 2011). The overall purpose of IO-MAP was to promote risk informed decisions in future IO collaboration environments (Rindahl, et al., 2009). Risk was defined as "… a combination of the frequency or probability of a specified hazardous event, and its consequences" (Storey, 1996, p. 60).

Overall, the capability of safe and attainable maintenance planning from onshore can be broken down into many elements such as man, process, organisation, governance and technology, all of these needing to be in place to ensure this capability. In the present study, focus is mainly on the technology element, along with man–technology interaction and performance (see further in the section "Background").

BACKGROUND

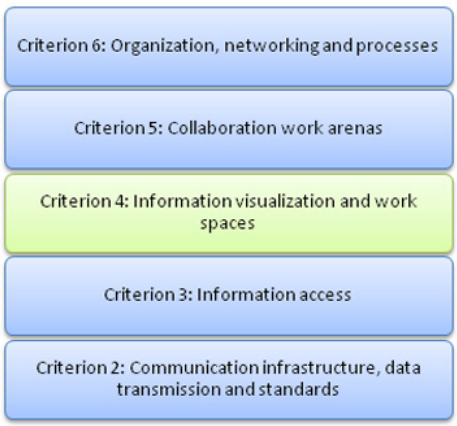
This section describes the background for the study. It contains three subsections: The first section, capabilities, situates the present study vis-à-vis the overall requirements for successful operation under IO. The second section, maintenance and modification planning, provides a generic description of the process of developing maintenance and modification plans at an IO installation today. Finally, section three, software tool, describes the software tool used in the study.

Capabilities

In Scandinavia, the term MTO has been used to describe human factors studies with reference to a system-oriented perspective (e.g., Rollenhagen, 1997). MTO is an abbreviation for man, technology and organization. "M" refers to the humans in the production process, "T" refers to technology applied (equipment and infrastructure), and "O" refers to the organization. Organizational processes, i.e., operational standards and means to achieve these, e.g., work processes, training schedules, and maintenance approach. The MTO perspective is highly influenced by cybernetics. It takes a holistic view on the organizational activities, and focuses on the relationship between each system element in the complex system rather than each system element itself.

Statoil's IO stack model makes up an MTO perspective of factors, which enable IO (Lilleng and Sagatun, 2010, p. 2), see Figure 1. The model consists of seven inter-dependent success criteria also referred to as layers. Together these criteria are believed to constitute necessary and sufficient conditions for value creation under IO. It is important for success to ensure that the criteria are

Figure 1. Stack model adapted based on Lilleng and Sagatun's (2010) pyramid of IO success criteria – Here with focus on the information and workspaces level



integrated both vertically and horizontally. From the bottom of the pyramid and towards the top, the criteria are as follows:

Criterion 1 states that for successful IO, one must be able to capture data (e.g. process and condition data) offshore for real time transmission to shore, and to remotely control relevant technology (e.g. sensors). In terms of safe and attainable maintenance planning from onshore these data may typically involve data on the state of the facility (e.g. integrity, condition of equipment) and the current environmental conditions (e.g. wind, wave height, temperature).

Criterion 2 is that the data needs to be communicated and usable, and this puts requirements on communication infrastructure, data transmission and on the standards for data and data communication.

Criterion 3 regards information access: Data needs to be successfully turned into information. For maintenance planning, this also means that data need to be turned into information that is usable for staff not situated offshore, and with limited facility knowledge.

Criterion 4 regards information visualization and workspaces. As information in an IO setting very often needs to be shared across disciplines and across geographical locations, new demands are put on workspaces and surfaces. Furthermore, in IO planning is a cross disciplinary activity, involving proactive and early use of information. To work well across disciplines and in mediated collaboration, visual interface technologies need to be user friendly, and to be able to present discipline specific information to multi discipline teams in ways that supports common understanding.

Criterion 5 regards collaboration work arenas, to which visual interface technologies are contributing. In our understanding, arenas encompass both the suitability and adaptability of physical collaboration rooms or equipment to meet the collaboration needs at hand, as well as the scheduling of collaboration sessions in the teams' work practices.

Criterion 6 concerns organization, networking and work process framework.

Criterion 7 relates to the mindset, leadership, and training of an organisation.

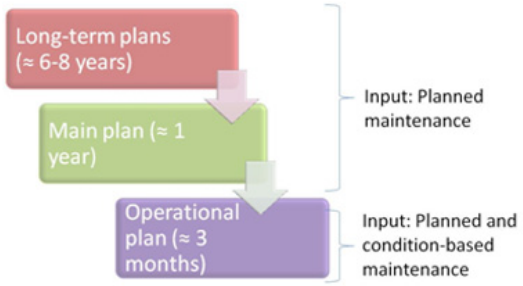
In this study, the focus is Criterion 4: Information workspaces, and in the described study, criteria 1 to 3 were assumed to be met at an adequate level.

Maintenance and Modification Planning

To understand how technology may best assist onshore planners, it is necessary to understand how onshore planners work. Onshore planners develop plans for performance of maintenance and modifications jobs offshore In terms of maintenance, the jobs can be split into two major groups: planned or preventive maintenance and condition-based or corrective maintenance. For each piece of equipment on a petroleum installation, a schedule for maintenance activities are defined based on recommendations from the manufactures of the equipment, legislation, and/or internal rule in the particular petroleum company. This schedule contains what is called the planned or preventive maintenance activities. They imply that maintenance is performed before a failure arises. Still, from time to time equipment may fail. When this happens, condition-based or corrective maintenance is performed to rectify (or isolate, etc.) equipment that has failed.

The present study focus on the development of 14-days plans. When onshore planners are engaged in development of 14-days plans work with reference to a set of overall plans (Sarshar & Sand, 2010; Sarshar et al., 2011; see Figure 2): Long term plans contain information about large project and turnarounds with a horizon of about 6-8 years. The main plan is a plan without obligation for contractors. Both the long-term plan and planned and preventive maintenance tasks provide input to the main plan, which has a horizon of one year. The operational plan receives batches of preventive maintenance tasks from the main

Figure 2. Factors which contribute to frame 14-day plans



plan in addition to corrective maintenance tasks and modification tasks planned onshore. At this stage, the tasks are committed with contractors, delivery plans for materials are made, personnel are allocated and work orders are defined.

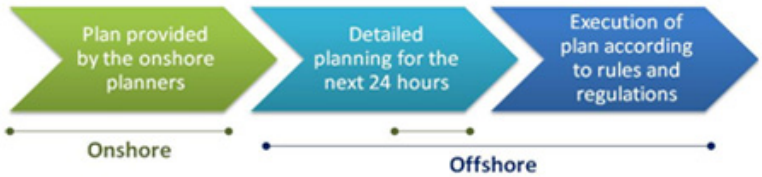
It should be noted that the above description accounts for maintenance and *minor* modification performed by personnel working on offshore rotation, and does not include the activities when planning campaign-based maintenance and modifications (i.e. work performed by onshore-based work force).

The plans generated by onshore planners are sent offshore. Offshore staff members modify the plan in a 24-hours perspective, based on concerns for safety hazards and to accommodate the current state and situation offshore (e.g., personnel being ill, tools needing repair, etc.). Offshore staff will focus on different types of hazards, including: hot work, i.e., operations which involve fire or spark producing, such as welding; work implying that the safety systems are shut down: process-related hazards (e.g., if a given valve is opened, the pressure at point 'X' has to be checked immediately), and issues related to emergencies, e.g., that the lifeboat may be inaccessible. If two or more tasks located nearby each other and/or on the same systems are to be performed simultaneously, offshore staff will meticulously check whether: (1) it may lead to dangerous situations, (2) it may imply that safety systems will be shut down, or (3) it may lead to confusion – e.g. that somebody may believe that other tasks are performed elsewhere, etc. Following the adjustment of the plan, onshore and offshore staff members agree on the plan, and the plan is executed (see Figure 3).

In a questionnaire survey, the eight participants in the current study (see subsection "Participants") were asked what aspects of the planning process they found to be most challenging (unpublished results from the first usability study of the IO-MAP, Skjerve et al. (2011)). The top-three challenges uncovered were:

- The need to revise plans due to unplanned for events (equipment failure, staff shortage due to high workload elsewhere, etc.).
- To get adequate/correct/sufficient information from offshore needed to develop sound plans.
- Implementation of the plan: To get people offshore to stick to the plan.

Figure 3. Sketch of a generic work process from 14-days planning to task execution



As part of the same survey, the participants were asked what they found to overall characterise a good plan. Two key issues emerged:

1. The plan should be realistic/attainable. Being realistic implies that the plan should be understandable to the personnel, who are going to implement it; that the resources needed for performance of the planned jobs are ensured; that the tasks contained in the plan are well coordinated –with respect to, e.g., the work required from the different disciplines (automation, electricians, etc.), and the overall distribution of workload across the disciplines.
2. The plan should be quality assured. This implies that prior to implementation, safety hazards should be identified, and that the plan generally should have a strong focus on Health Safety and Environment (HSE).

In addition, the participants emphasized that a good plan should be well-coordinated with other long-term plans (see Figure 2) and agreed upon by the staff involved.

Software Tool

IO-MAP is a software tool designed to promote the process of planning maintenance and modification activities. The IO-MAP was developed by Institute for Energy Technology (IFE) as a part of the project Future Collaboration Environments in the IO-CENTER at NTNU, Norway (Rindahl, et al., 2009; Sarshar et al., 2010; Skjerve et al., 2009). The first version of the IO-MAP was used as testbed in the present study, and in the following, the all descriptions of the IO-MAP will refer to this version of the tool.

The IO-MAP is designed to function both as a groupware technology and as a technology to support individual planners. Groupware technologies can be defined as "... software applications that are able to facilitate collaboration among groups of people over the Internet" (Blake and Rapanotti, 2004, p. 500), or – as in the present case – over a restricted computer network. If was necessary that the IO-MAP both supported groups of staff and individuals engaged in planning, to reflect the typical work process associated with maintenance and modification planning under IO. In this study, focus is solely on the support, which the IO-MAP provides to the onshore planners engaged in planning of maintenance and modification activities.

The overall purpose of the IO-MAP was to promote risk informed decisions in future IO collaboration environments. Risk was defined as "… a combination of the frequency or probability of a specified hazardous event, and its consequences" (Storey, 1996, p. 60). The IO-MAP was intended to achieve its goal by presenting safety standards, job locations and occupational hazards in a manner to support identification through pattern recognition and by carefully highlighting key information only, increasing the total risk understanding without alarms and pop ups which may eventually lead to a false or incomplete risk understanding of the complex situation on the installation (Rindahl et al., in press). The term risk visualization traditionally refers to the systematic effort of using (interactive) images to augment the quality of risk communication along the entire risk management cycle (Eppler and Aeschimann, 2008, p. 4), and much of the work on operational risk visualization focus on calculated risk.

For technology to promote onshore planners' ability to address offshore safety hazards, our hypothesis was that the system should support the onshore planners in two overall respects. It should:

1. Promote onshore planners' understanding of the offshore work situation resulting from the generated plan.
2. Promote onshore planners' insights into the safety rules that govern offshore performance.

The tools currently used by most onshore planners list the jobs using tables, and use Gant diagrams to present the job schedules (e.g., Safran Planner ™, SAP™, and Microsoft Project™). These require high competence and tool experience to extract important information with respect to planning jobs with safe operation. The IO-MAP contains a Map Area, which represents a deck on the installation (see Figure 4, upper part). The Map Area shows where tasks, which require work permits, are located and allows the planner to navigate through different decks. The IO-MAP testbed contains two decks: Basement deck and Mezzanine deck. The IO-MAP further allows the planner to consider the plan as it progresses day by day, to determine if any safety hazards remain unaddressed. As a rule, all tasks that involve or may involve a safety hazard should have a work permit. The activities that may be performed without work permit will generally be routine operations within production, drilling, logistics or marine, where the work is carried out according to procedures and requirements (OLF, 2003).

To promote understanding the safety rules governing performance offshore, the rules are as far as possible (from the perspective of the user) visualized automatically directly at the Map Area. These rules were identified based on information about the characteristics of the installation and the standards of the organization in charge of the operation. Three different types of elements were used in the visualization progress: connectors, prohibits and hazards (see Figure 5). A connector is represented in the form of a line between two tasks and represents a hazards related to these tasks, e.g., that they are performed simultaneously or in a particular sequence. If one task is moved until after the other is finished, the connector will disappear. Prohibited presents marking initiatives, e.g., wearing a safety helmet, mandatory when working in a particular area/with a particular task. Hazard represents a safety hazards associated with the individual task (see Figure 5). The hazards and prohibited elements are illustrated with a hazard triangle on the task displayed in the Map Area. In addition, hazards associated with a particular location on a deck, e.g., the risk for ignition, or noise level, could be shown as background on the Map Area view, using zone classification overlay and noise classification overlay, respectively. In situations where the onshore planners identified hazards, prohibitions and/or connections, which were not marked in the Map Area, he or she was requested (during the scenario) to add these.

Figure 4. The IO-MAP testbed



A fourth element was used to represent information provided by the previous participants (fictive in the study) of the IO-MAP and the current participant. By clicking on the related icons (see Figure 5), the onshore planner may be informed about safety hazards and/or other types of issues of concerning safety (e.g., reminders about checking particular issues) identified by colleagues.

METHOD

Participants

In total eight participants took part in the study. The participants were from four different petroleum companies: Eni Norge, GDF SUEZ, Shell and Statoil. The participating planners took part in the study individually. They were selected for the study by representatives from the petroleum companies engaged in the IO centre, from their pool of potential future users of IO-MAP. Except for one participant, all participants held a job in which they were involved in planning of offshore tasks from onshore today.

The age of the participants ranged from 25 to 61 years, with an average of 38.4 years. They had between 3 and 30 years of experience from the petroleum industry, with an average of 12.1 years. All participants had higher technical educations.

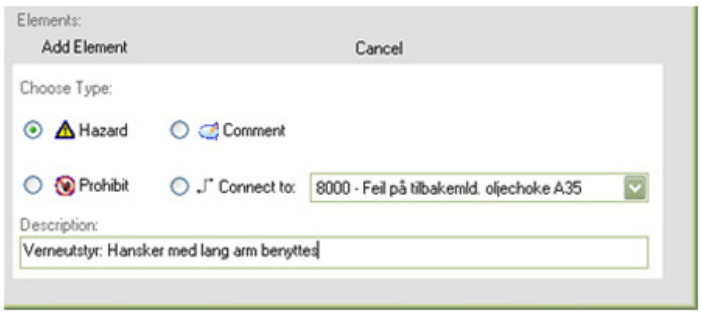
The offshore experience of the participants differed. Three of the participants had been working offshore during their carrier in periods from 6 months to 2 years. The remaining five participants had made field visits to the installation they worked for (as well as to all other installations they had worked for) to increase their familiarity with offshore work, as well as the local conditions.

Scenarios

The study included two scenarios. The scenarios were developed in close collaboration with highly experienced staff from the petroleum industry. They were designed to fulfil three criteria:

1. They should appear realistic to the participants, i.e., the situations included in the scenarios should seem plausible to the participants.
2. Handling of the scenarios should to the extent possible involve the same cognitive activity, as it would, if the scenarios unfolded in the normal work environment of the participant.
3. The joint performance of the scenarios in the evaluation session should ensure that all functions of the IO-MAP testbed (most likely) would be applied during the evaluation sessions.

Figure 5. Excerpt of the IO-MAP for adding a new element to a work permit



The two scenarios were of approximately 30-40 minutes duration. Each scenario contained a given plan of jobs. The participants were instructed to evaluate the quality of the plan, and change the sequence of jobs if this deemed necessary. In both scenarios, a range of adjustments would be required avoid risk situations.

Each scenario was designed to contain a number of "basis events", which jointly constituted a set of jobs, which the participant might realistically face in a planning situation in a normal working day. In between these tasks, so called "Easter Eggs" were imposed. Easter Eggs constitute jobs with inherent hazards that (it was assumed) would not be obvious to the participants at a first glance.

The type of hazards applied included, e.g., a potential for falling objects and situations where hot work and other tasks were planned to be performed simultaneously in areas of the platform where they would be risk for ignition.

All scenarios started with the zone classification overlay on the Map Area.

Procedure

A standard time schedule was applied for each participant: Following a short introduction to the study, which included information about ethics and the signing of a consent form, the participant has around 40 minutes training in how to operate the IO-MAP. Then the first scenario package was performed. A scenario package included one scenario lasting around 35 minutes, a short interview about detections and actions during scenario immediately following the completion of the scenario and a questionnaire session. After the lunch break, a second scenario package was carried out. Following completion of the scenario packages, a longer interview session was performed (around 45 minutes). The study was rounded off with a 10 minutes debriefing and adjourning session. In all, the participants took part in the study for 4 hours. During the study, the time schedule was, however, adjusted for several of the participants. The standard schedule was adjusted during the performance of the study based on situational factors, e.g., when a participant had to take care of urgent incoming day-to-day tasks. This implied that only four of the participants performed both scenarios (see Figure 6).

Eight participants took part in the 1st usability evaluation, which included 13 scenario runs. Ideally, all the eight participants should have performed the two scenarios included (Planner-1 and Planner-2), but for practical reason this turned out not to be possible for four of the eight participants. Two scenarios were applied. These where to the extent possible administered interchangeably to the participants (see Figure 6).

As a part of the introduction, the participants were asked to imagine that they were operating in a future setting in which the onshore planners' task implied identification of safety hazards – or potential safety hazards - as early in the planning process, as possible.

Figure 6. Run plan for the 1st usability evaluation of the IO-MAP

Participant No.	Scenario No.	Run No.
1.	Planner-1	01
1.	Planner-2	02
2.	Planner-2	03
2.	Planner-1	04
3.	Planner-2	05
4.	Planner-1	06
4.	Planner-2	07
5.	Planner-2	08
5.	Planner-1	09
6.	Planner-1	10
6.	Planner-2	11
7.	Planner-2	12
8.	Planner-1	13

Measurements

Data were collected using questionnaires administered to the participants, expert ratings, system logs, and interviews with the participants (see Figure 7). For practical reasons, data for assessment of performance quality based on expert judgements and logs on system use were only collected in run 6-13.

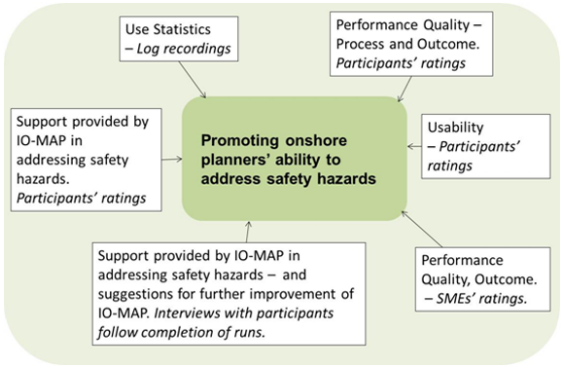
The *performance quality* of the participants was assessed based on expert judgments of the quality of the final plan resulting from each of the eight scenarios performed in run 6-13. The assessment was performed in a group setting, and the evaluation process was structured by an evaluation form. For each scenario, the expert group addressed three issues:

1. How would you characterize the *safety hazards* associated with performance of the final plan?
2. Can the plan be approved?
3. How would you characterize the adequacy of the final plan from the perspective of *potential production loss*? (only relevant, if the response to question number 2 was "yes.")

For items 1 and 3, the group responded using a seven-point, ordered, one-dimensional scale. In addition, the experts were asked to state the reason for the score they provided, using free text. Performance quality was, moreover, assessed by the participants. Following each scenario the participants were asked to assess the quality of their own work process using IO-MAP, as well as the outcome, i.e., their resulting plan, on two questionnaire items (see section "Results and Discussion")

The extent to which the IO-MAP supported the participants in addressing safety hazards was assessed based on the participants' judgements. Following each scenario, the participants were also asked to assess to what extent the IO-MAP

Figure 7. Overview of the data collection techniques applied



promoted their ability to identify safety hazards and safety-related rules/standards (see section "Results and Discussion"). Data on this issue was also obtained from a semi-structured interview, performed with each participant when following completion of all (one or two) scenarios. The participants were asked to which extent the IO-MAP had helped them in addressing safety hazards, and asked to provide examples to facilitate understanding of their judgements. They were also asked to elaborate on the reason the scores they provided on the three related questionnaire items. Finally, they were asked to suggest how the IO-MAP might be improved to promote their ability to address safety hazards even more.

Use statistics was applied to obtain information about the extent to which the various functions offered by the in IO-MAP was used, during the scenarios in run 6-13.

Finally, the System Usability Scale (SUS) (Brooke, 1996) was used to provide a global measure on the usability of the IO-MAP. SUS is a low-cost usability scale that can be used for global assessments of systems usability. The questionnaire assesses usability to one overall dimension only, i.e., the score on all items is jointly interpreted as a measure of the system's usability. SUS consists of ten questionnaire items formulated as statements concerning the user's experience with

using a computer system. The user responds on a 5-point scale, to the items on a rating scale from 1 (Strongly Disagree) to 5 (Strongly Agree).

RESULTS AND DISCUSSION

The research question of the study was: How onshore planners' ability to address offshore safety hazards can be promoted by the use of visualization technology during development of 14-days plans. Within the framework of a study where IO-MAP served as case, the research question was interpreted to focus mainly on the participants' use of and evaluation of the Map Area, where safety hazards were visualised.

The usability study had already shown that the Map Area was the design attribute of the IO-MAP, which the participants by far appreciated most (Skjerve et al., 2011). The participants emphasized that they did not presently have a design attribute like the Map Area at their disposal, and that they wanted this attribute to be a part of their planning tools. In the interview session, the participants emphasized that the Map Area was a highly effective design attribute to support the onshore planners in addressing safety hazards as part of the planning process.

To facilitate interpretation of the results, the research question was decomposed into three inter-related parts:

1. Did the IO-MAP promote onshore planners' understanding of the work situation offshore, which resulted from the plan?
2. Did the IO-MAP promote onshore planners' insights into the safety rules that applied to the plan?
3. Did the participants manage to develop plans, in which all safety hazards were adequately addressed using the IO-MAP?

This section will present and discuss the outcome of the study.

Promoting Onshore Planners' Ability to Understand the Overall Offshore Work Situation Resulting from a Plan

The extent to which the IO-MAP promoted the planners' ability to understand the work situation offshore, which results from the plan being considered, i.e. the distribution of activities in space and time, was addressed during the interview session. The participants reported that the Map Area was seen as an effective design attribute to convey an overview of the location of tasks on an offshore installation and was a highly useful visual reminder of the jobs – and the inter-relations between the jobs - being planned.

When initiating a scenario, the zone classification overlay was presented as a default to the participants. They could thus select noise – and return to zone classification later. The use statistics showed that in three of the eight runs (i.e., in run 6-13, both included, see run plan on page 10), the noise classification overlay was used by the participants. This was as expected, given the content of the scenarios. It, moreover, showed that the deck displayed on the Map Area was changed in five of the eight scenario runs (see Figure 8).

Figure 8. The participants' use of the functions in IO-MAP during run 6 to run 13 (both included)

IO-MAP function	Used	Used in no. runs
Select noise classification overlay on the Map Area	10	3
Select zone classification overlay for the on Map Area	7	2
Change deck on the Map Area	15	5

Changing decks was a function required to solve one of the scenario correctly, which involved the hazard "falling objects". The interview showed that the participants tended to forget that tasks could be located at other decks, and that this function was used much more sparsely than would have been ideal.

The participants suggested a range of ways in which visualization of tasks at the Map Area could be improved to better support their ability to address offshore safety hazard (see bullet points below). The suggestions tended to concern design of the Map Area – and thus visualization technology – directly (Criterion 4). However, implementing the desired design attributes would also come to change the onshore planners' ways of working (Criterion 6):

- Overall, most participants desired a more detailed representation of equipment, rooms/divisions, than presently contained in the Map. Most of the users would ideally have preferred to have the tasks visualized in a 3D model of the installation
- At the Map Area only tasks requiring a work permit were visualized. The participants suggested that tasks, which are routinely carried out on an everyday basis, and do not require work permits, should also be represented: If these tasks are performed within an area where hot work is planned the staff doing the routine tasks may be at risk.
- One participant wanted to see notifications represented in the Map Area (see section "Background").
- It was suggested that the Map Area should contain photos, videos (if relevant) and drawings of the equipment. These should be available to the users by double clicking on the various tags within the Map Area. This type of information was seen as useful to assist employees who had limited familiarity with the platform in question in understanding the platform's characteristics
- More participants suggested that historic data about how the particular job being planned had been performed earlier should be added, e.g., SJAs (Safe Job Analyses). The argument was that this information would promote the onshore planners' ability to identify the safety hazards associated with the given job.
- The participants much appreciated the depiction of zones.

In general, the Map Area was judged by the participants as a design attribute that supported both learning, in the form of gaining familiarity with the installation, and the retention of the material learned (Criterion 7). Today, onshore planners' familiarities themselves with the installation they plan for by paying visits to the installation with different intervals. The Map Area was seen as an effective design attribute both to remind the onshore planners' about the installation's layout, and to facilitate retention of the insights they had gained during their field visit(s). The Map Area was thus, overall, seen as an efficient tool for promoting the onshore planners level of familiarity with the installation.

The participants provided suggestions, which would support planning in a shorter-term perspective, than 14-days, and thus part of the planning process, that is typically performed offshore today:

- To include representations of wind, waves, and temperature in the Map Area, as these factors impact the possibility for performing tasks and/or the duration of a task (e.g., in cold weather task performance may have to be interrupted at regular intervals for people to get some warmth; high-waves combined with work over sea implies that a standby boat should be present).
- To apply real time data to continuously show the progression of the performance

of the plan tasks in the Map Area, to promote the planners' ability to develop better plans in terms of resource distribution and to correctly address safety hazards.

The participants further considered the usefulness of the Map Area from a multi-user perspective. They found that the Map Area was a design attribute that could markedly promote collaboration between the stakeholders involved in a planning process (Criterion 5) (Skjerve et al., 2011). The Map Area was believed to offer a common reference for staff members from various disciplines, holding various roles and with different levels of familiarity with the installation [1] (see further Rindahl et al., in press). The participants, moreover, suggested that the Map Area showing on-going rather than planned tasks, should be displayed in relevant rooms onshore (and possibly offshore too) to promote shared understanding of the situation at hand between staff members across locations. They also suggested such displays could be used to explain visitors what the offshore installation looked like, and provide an overview of the on-going activities offshore.

To summarize, the results suggest that the IO-MAP does promote onshore planners' understanding of the work situation offshore created by the plan. The participants emphasised that the Map Area provided them with a good overview over where the different jobs should be performed. They stressed than in particular for planners, who had limited familiarity with the installation in question, the representations on the Map Area were useful.

Promoting Onshore Planners' Insights into the Safety Rules Governing Offshore Performance to Adequately Constrain the Plans Developed

Safety hazards were visualized on the Map Area using icons, which represented the elements hazard, prohibit, comment, and lines, which represented connections between two tasks that implied a safety hazard.

The elements hazard and prohibit were as far as possible automatically represented on the Map Area. In situations where a participant identified a hazard or a prohibition, which were not marked in the Map Area, he or she was expected to add these to the Map Area. In addition, a set of connections was automatically displayed. These connections implied that if the two connected tasks were to be performed according to the current plan, it would imply a safety hazard. The participants were likewise expected to add further connections, if needed. Finally, the participants were expected to add comments, which contained information that could be of importance for addressing hazards (e.g., issues to remember, information obtained from field staff). All of these activities were assumed to promote the visibility of safety hazards and help ensure that these were addressed. The number of times the participants actively used (changed) the various elements, shown as icons or lines on the Map Area view, can be seen in Figure 9.

From Table 3 it can be seen that the hazard element was used only by three participants (i.e. three runs). A participant explained that this function was more relevant for the person who was going to perform the tasks, than presently for onshore planners. The participant explained that the planners, e.g., do not concern themselves with the need for drainage of a tank before a task is performed. They take it for granted that the persons, who are going to perform the tasks in practice, are aware of and will take care of this. For this reason, marking "not draining" as a safety hazard in the above example would generally be perceived as completely unnecessary. Another participant explained that he did not use the hazard element, because the risks associated with the different tasks were addressed by a particular group of staff dealing with work permits in his company. For this reason, this participant found that if he used the hazard element he would some-

Figure 9. The participants' use of the elements in IO-MAP during run 6 to run 13 (both included)

IO-MAP function	Used	Used in no. runs
Add comment	19	6
Add prohibit	0	0
Add hazard	12	3
Add connector	15	7
Edit connector	2	2
Edit comment	3	1
Edit prohibit	0	0
Edit hazard	5	2
Remove element	2,75	2

how come to "overrule" the decisions made by this group. Rather than this, he used to comment element to document hazards, he had identified.

The reason why the hazard element was not used, thus, mainly seems to be because the participants did not perceive this function to be relevant for onshore planners. This implies that requesting the participants to imagine them being in a future setting, where they should identify potential safety hazards during the planning process, did only succeed in 3 out of 8 case.

The prohibited element was not used at all during the study. During the interview session, it became clear that the participant did not understand this element. The line of thinking behind the element was specifying prohibited activity, e.g., in particular areas of an installation it is not allowed – and thus prohibited - to work without wearing a safety helmet. The lesson learned was it might be better to formulate this type of information in terms of what people should do – e.g., they should wear a safety helmet – rather than in terms of what was prohibited. Still, this element will – as the hazard element – also be considered as relevant for offshore staff – rather than onshore planners – when working within reference to the today's setting – rather that the future setting intended in the study.

The comments element was, however, used in all except one of the scenario runs being logged (see Figure 9). In this field, the participants noted different types of issues to attend to, to – more or less directly - avoid potential hazards. The comments could, e.g., concern a reminder to check the outcome of a particular task, prior to making a final decision with respect to the inclusion or timing of a given task. During the interview sessions, the participants stressed that they appreciated the possibility for freely entering any type of information they found to be important or potentially important in relation to the given task. The participants had some suggestions for improvement of the comment element:

- A participant asked for an element which was "something more than a comment" – e.g., "critical comment" to increase the likelihood that the text would actually be read by colleagues, during later phases of the planning process.
- Several participants suggested that it should be clear who had entered the comment. Knowing the author's identity was seen as a potentially important factor in help to interpret the content of a message.
- On a more general level, it was suggested that the role an individual holds in the organization, should determine his or her access to the various functions contained in the IO-MAP. Thus, only some employees should have the authority to plan tasks, whereas all employees should be able to enter a comment.

The possibility for connecting two tasks was used frequently, i.e., in seven of the eight runs

logged, and in all fifteen times, in addition to an existing connection being edited two times (see Figure 9).

Connections were automatically displayed on the Map Area as a line between two tasks. A connecting line signified that if the two connected tasks were to be performed according to the current plan, it would imply a safety hazard. Still, the study showed that even though the participants used connections often, they largely used them differently than intended. The participants did apply connections to signify a relationship between two tasks – but the relationship was typically of a practical nature (e.g. the performance of one task, was a precondition for performing of the other), rather than a relationship, which implied a hazard. The interview sessions suggested two main reasons why connections were used in this way: (1) most onshore planners have a connection option available in the systems they use on a daily basis, which they use to specify practical relationships between tasks (e.g., dependencies between work orders and work permits, (2) onshore planners are not used to specify this hazards in the plan they produce today. Overall, the participants emphasized that the found the connection function useful – both to specify practical and safety-related dependencies between tasks. They had some suggestions for how to improve the use of connections on the Map Area:

- Distinguish between connections of different types, e.g., use different colours on the connecting lines, when a dependency between two tasks signifies a safety hazard, and when it signifies a practical issue (e.g., tools or staff will be available to perform a given task only, when another task has been completed). This type of distinction was suggested to promote the participant getting an overview of all the connections contained on the Map Area.
- Connections should be expanded to include hazards that are related to tasks performance on different decks – not only to tasks that are performed at the same deck. This would allow display of the hazard for falling objects. Related to this, it was moreover suggested that safety-zones around area where object may fall due to crane lift, should be shown on the Map Area. Jointly, these functions expected to markedly facilitate the onshore planners understanding of task performance on the offshore installation, and thus promote his or her ability for foresee hazards.

The outcome of the questionnaire survey indicated that the IO-MAP overall – as judged by the participants - succeeded in promoting the participants' ability to identify safety hazards sooner, than they would otherwise have done (see Figure 10).

The study showed that onshore planners saw a need for augmenting present tools used for planning with functionality as provided by IO MAP, and in particular IO MAP's Map Area. They also found that such design features had a poten-

Figure 10. Items used to assess the participants' evaluation of the quality of IO-MAP

Item and response scale end-points	Valid N	Mean	Min.	Max.	Std. Dev.
In general, the IO-MAP showed me safety hazards before I had managed to identify these on my own.	8	5,2	4	7	1,00
In general, the IO-MAP showed me rules/standards (by use of icons) before I had come to think of them.	8	5,2	4	6	0,84

tial for raising onshore planners ability to address safety hazards already at their own stage of the planning process.

Performance Quality and Usability Assessment

The extent to which the Map Area promoted the participants' ability to accurately identify and address safety hazards is a question of key concern. It is important that the participants perceive the Map Area as useful, but to have positive impacts in practice, the plans developed when working with the Map Area, must also be sound. In practice, the impact of the Map Area cannot be distinguished from the impact of the IO-MAP overall on the plan developed. Thus, the question concerning whether sound plans were developed, was redefined to the following: Did the participants manage to adequately identify and address all safety hazards in the scenarios, when working with the IO-MAP?

A group of experts jointly evaluated the quality of the final plans following each of the scenarios from run 6 to 13, in all 5 different participants. The outcome of the expert group's evaluation processes is reported in Figure 11.

The result for Planner-1 scenarios was slightly above average, where as the result for Planner-2 scenarios was exactly average. This signifies that not all hazards have been adequately attended to in the plan (score: 7), but that some – rather than none (score: 1) – of the hazards have been adequately attended to. In planner 1 Scenarios, none of the final plans - except for the one developed by participant 8 – were judged to be implementable in practices, i.e., approvable. In relation to the Planner 2 scenarios, this is not a relevant issue, because the resulting plans are not expected to be approvable.

It was clear that the participants rarely had attended to the tasks located at the deck above the Basement deck, which were displayed when

Figure 11. Performance quality rated by a group of experts. Legend: Q1) How would you characterize the safety hazards associated with performance of the final plan? Q2) Can the plan be approved? Q3) How would you characterize the adequacy of the final plan from the perspective of potential production loss? Note, the third question is only relevant, if the response to Q2 is "Yes."

Scenario:	Planner 1			Planner 2	
	Q1	Q2	Q3	Q1	Q2
Participant 4	1	No	-	4	N/A
Participant 5	4	No	-	5	N/A
Participant 6	6	No	-	3	N/A
Participant 7				4	N/A
Participant 8	7	Yes	7		
Average	**4,5**			**4,0**	

the scenarios were initiated, even though the participants in five runs (runs 6 and 10-13) actually changed deck (see Figure 8). This suggests that including visualization of the hazard "falling objects" should contribute to further improve the onshore planners' ability to address safety hazards offshore. In a broader perspective, it also indicates that the part of the deck on which there is a risk of falling objects due to crane lifts, should be visualized. It was, moreover, clear that hazards such as, e.g., the need to avoid the performance of a task in areas were hot work was being performed, were in many cases not addressed in the plan. In both of these cases, the most likely interpretation is that the onshore planners found it difficult to focus on safety hazards as part of the planning process, and to some degree tended to fall back on well-known work routines (where offshore staff will address the issue of safety hazards later in the process).

Following the completion of each scenario, the participants were asked to assess the quality of the planning process as well as the outcome of the planning process, see Figure 12. The outcome show that the participants responded either neither agreed nor disagreed with the statement (a score of 4) or agreed completely with the statement (a

Figure 12. Descriptive statistics for item on support to generate sound plans. Response scale end-points: (1) Completely disagree. (1) Completely agree (7.)

Item and response scale end-points	Valid N	Mean	Min.	Max.	Std. Dev.
Overall, the IO-MAP provided me with very good support to generate plans in which safety were well ensured.	8	5,6	4	7	1,12

score of 7). The average score was 5,6, which implies that the participants in average tended to agree more than disagree with the statement.

The participants view on the general usability of the IO-MAP may be used to refine their views on the support provided by the IO-MAP in the planning process, as this question was in focus during the usability assessment. The descriptive statistics for the scores provided on the System Usability Scale (SUS) is provided in Figure 13.

The IO-MAP obtained a SUS score of 80,3. According to Bailey (2006), the average satisfaction scores are usually between 65 and 70, and the IO-MAP score is thus well above average. Thus, overall the planners were very satisfied with the IO-MAP.

Also the performance data and usability assessment thus indicate that IO MAP type tools may contribute to the capability of onshore planners to address safety hazards early on in the planning process. The high usability score may also indicate that such tools would indeed be employed by the users if available. Still there were hazards that were not uncovered by all planners.

RECOMMENDATIONS AND FUTURE RESEARCH DIRECTIONS

The study addressed the capability of safe and attainable onshore planning of maintenance and modification activities on an offshore installation.

From the perspective of individual onshore planners, the study suggested that visualization of each job on a representation of the location at which the job should be performed, combined with indications of associated safety hazards (if any) (i.e., the Map Area), could promote onshore planners' ability to understand the work situation offshore that will be implied by the plan they generate. Onshore planners typically visit the offshore installation they plan activities on for shorter periods only to gain familiarity with its layout. During the study, the planners argued that the visualizations on the Map Area would help them retain the insights they gained during their offshore visits by reminding them about the layout, but also that the visualizations would refine their insights (e.g., by making clear relationships sites and/or systems).

The increased insights into the characteristics of the offshore installation could be expected to facilitate communication about jobs – including the associated safety hazards – between onshore planners and staff involved in planning offshore.

Figure 13. Descriptive statistics for SUS

Item no.	Valid N	Mean	Minimum	Maximum	Standard Deviation
1	8	4,13	2	5	0,99
2	8	4,38	2	5	1,06
3	8	4,38	4	5	0,52
4	8	4,25	2	5	1,04
5	8	3,88	3	5	0,83
6	8	4,00	2	5	0,93
7	8	4,63	3	5	0,74
8	8	4,63	4	5	0,52
9	8	3,75	2	5	0,89
10	8	4,13	3	5	0,83

Moreover, the representations on their own would provide a common reference for these dialogues and thus contribute to reduce the risk for misunderstandings.

At a departmental level, the participants suggested that the Map Area with representation of on-going (rather than planned) tasks might be displayed on common walls onshore and offshore (if relevant) to promote the general understanding of the situation offshore in the organization. Using the displays in this way might in general contribute to promote communication flow within and between departments, as it promotes individuals ability to understand (and remember), if information they have available might be of relevance for the flow of work offshore.

Another major potential positive impact of improving onshore planners' ability to understand the work situation offshore implied by a plan - including safety hazards – is that the plans they generate might be more *robust*, i.e., in the sense the fewer tasks would have to be send to re-planning. Today offshore staff frequently sends tasks back to re-planning, as the tasks for one reason or the other cannot be performed. This may across time result in large backlogs containing tasks that *should* have been performed earlier. If tasks remain in the backlog they may get more critical for ensuring safe and efficient performance. If fewer tasks are send to re-planning, it would thus contribute to reduce the backlog and thus the risk that critical tasks are left unaddressed for too long. In this way design attributes like the Map Area might help to ensure improved plan attainment.

Finally, several of the participants suggested that the Map Area should be substituted by a full 3D model of the installation in future versions of the IO-MAP. A task for future research would be to compare tasks performance of onshore planners working with a 2D representation (as in the Map Area) and a 3D model to explore the impact of a 3D model on the participants' ability to develop safe and attainable plans. Further planners stressed that also routine tasks (which were not represented in the present model), should be included. Comparing the two cases – with and without routine tasks – might also an issue to be addressed by future studies.

CONCLUSION

This chapter concerned the capability of safe and attainable maintenance and modification planning. It focused on how onshore planners' ability to address offshore safety hazards could be promoted by use of visualization technology. Findings were based on data obtained in a usability study using the IO MAP.

The outcome of the study suggests that design attributes such as the Map Area, serve to promote onshore planners' ability to address offshore safety hazards. Two main principles formed the design of the Map Area: to visualize the geographical location of the planned jobs on the given deck, and to visualize safety hazards jointly with the jobs.

The study suggests that the visualization of the geographical location of the planned jobs promoted onshore planners' understanding of the work situation implied by a plan. It further suggests that the visualization could support onshore planners' retention of insights gained from field visits, and potentially expanded their familiarity with the installation by adding knowledge about the characteristics of the installation. The study further suggests that visualization of safety hazards, using dedicated icons and lines jointly with the planned jobs, supports onshore planners' ability to address offshore safety hazards. The participants reported that the icons and lines helped them to identify safety hazards and identify these faster, than they would otherwise have done. The majority of the safety hazards contained in the two scenarios had been adequately addressed by the participants, but except for one participant, *none* of the participants succeed in adequately addressing all the hazards

contained. Still, overall the result was judged to be surprisingly good, both because addressing safety hazards at this level of detail was new to the participants, and because the task implied that they changed the well-established (current) way of working with (imagined) offshore staff members.

Even though the outcome of the study seems to clearly indicate that the Map Area – and the IO-MAP as such – is a very useful tool to onshore planners, the results should be considered with care. The study included eight participants and thirteen runs only. The participants may, moreover, not necessarily be representative of the group of onshore planners. They were selected by the participating petroleum companies from the Criterion that they should be potential users of the IO-MAP in the future. As a consequence, the participants *as a group* possibly had more offshore experience than most onshore planners.

Still, the results obtained across the participants all pointed in the same direction, which add to their credibility: All the participants provided very positive evaluations of the IO-MAP – in particular of the Map Area. They all reported that design attributes as the Map Area would promote onshore planners' ability to address offshore safety hazards, and emphasised that showing the location of jobs on a map of the decks and illustrating safety hazards were useful aspects to onshore planners.

REFERENCES

Bailey, B. (2006). *Getting the complete picture with usability testing*. Retrieved December 26, 2011, from http://www.usability.gov/articles/newsletter/pubs/030106news.html

Blake, C. T., & Rapanotti, L. (2004). Usability evaluation of distributed groupware in distance learning. In Y. Akpinar (Ed.), *Proceedings of the Fifth International Conference on Information Technology Based Higher Education and Training* (pp. 500–504). New York, NY: IEEE.

Brooke, J. (1996). SUS: A "quick and dirty" usability scale. In P. Jordan, B. Thomas, & B. Weerdmeester (Eds.), *Usability evaluation in industry* (pp. 189-194). London, UK: Taylor and Francis. Retrieved December 26, 2011, from http://hell.meiert.org/core/pdf/sus.pdf

Drøivoldsmo, A., Kvamme, J. L., Nystad, E., Lunde-Hanssen, L. S., Larsen, R., & Berge-Leversen, T. (2007). *Integrated operations and insights on functional analysis techniques.* Paper presented at the Joint 8th IEEE Conference on Human Factors and Power Plants and 13th Annual Workshop on Human Performance, Monterey, CA.

Edwards, T., Mydland, Ø., & Henriquez, A. (2010). *The art of intelligent energy (iE) – Insights and lessons learned from the application of iE.* SPE 128669. Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Utrecht, The Netherlands, 23-25 March, 2010.

Eppler, M. J., & Aeschimann, M. (2008). *Envisioning risk: A systematic framework for risk visualization in risk management and communication.* ICA Working Paper 5/2008. Retrieved December 26, 2011, from http://www.knowledge-communication.org/pdf/envisioning-risk.pdf

Holst, B., & Nystad, E. (2007). *Oil and gas offshore/onshore integrated operations – Introducing the Brage 2010+ project.* Paper presented at the Joint 8th IEEE HFPP / 13th HPRCT.

Khan, F. I., & Haddara, M. M. (2003). Risk-based maintenance (RBM): a quantitative approach for maintenance/inspection scheduling and planning. *Journal of Loss Prevention in the Process Industries*, *16*, 561–573. doi:10.1016/j.jlp.2003.08.011

Lilleng, T., & Sagatun, S. I. (2010). *Integrated operations methodology and value proposition.* SPE 128576. Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Utrecht, The Netherlands 23-25 March 2010.

OLF. (2003). *OLF Anbefalte retningslinjer for felles model for arbeidstillatelser (AT), rev. 2., nr. 088*. Norwegian Oil Industry Association.

OLF. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf. 20.10.05*. Stavanger, Norway: Oljeindustriens Landsforening.

OLF. (2008). *Integrated operations in new projects, Draft version 0.2 Open for comments*. The Norwegian Oil Industry Association.

Rindahl, G., Skjerve, A. B., Sarshar, S., & Braseth, A. O. (2012). Risk informed decisions in future collaboration environments – Mapping of information and knowledge onto a shared surface to improve planner's risk identification. *Integrated operations: Risk, safety and resilience,* in press.

Rindahl, G., Skjerve, A. B. M., Falmyr, O., Nilsen, S., Sarshar, S., Randem, H. O., & Braseth, A. O. (2009). *Studies on the effects on risk identification in team decision processes when applying risk visualisation technologies to support long and short term maintenance planning in future integrated operations in the petroleum sector*. White Paper No. P4.1-001:IO Center.

Ringstad, A. J., & Andersen, K. (2006). Integrated operations and HSE – Major issues and strategies. Paper presented at the SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production (SPE 98530). Abu Dhabi, U.A.E., 2-4 April 2006.

Ringstad, A. J., & Andersen, K. (2007). *Integrated operations and the need for a balanced development of people, technology and organization.* Paper presented at the International Petroleum Technology Conference held in Dubai (IPTC 11668.), U.A.E., 4-6 December 2007.

Rollenhagen, C. (1997). *Sambanden människa, teknik och organisation - en introduktion* (second reprint). Lund, Sverige: Utbildningshuset, Studentlitteratur.

Sarshar, S., & Sand, T. (2010). Communicating risk in planning activities distributed in time. In *Proceedings of Risk, Reliability and Societal Safety*, ESREL 2010, September 5-9, Rhodes, Greece, (pp. 2033-2038).

Sarshar, S., Sand, T., Skjerve, A. B., Rindahl, G., & Hermansen, B. (2011). Quality aspects in planning of maintenance and modifications on offshore oil and gas installations. In Bérenguer, C., Grall, A., & Soares, C. G. (Eds.), *Advances in safety, reliability, and risk management*. CRC Press. doi:10.1201/b11433-245

Skjerve, A. B., & Rindahl, G. (2010). *Promoting trust between members of distributed teams. Lessons learned from an exploratory study in the petroleum industry*. Paper presented at the 2010 IEEE International Conference on Systems, Man, and Cybernetics, 10-13, October 2010, Istanbul, Turkey.

Skjerve, A. B., Rindahl, G., Randem, H. O., & Sarshar, S. (2009). *Facilitating adequate prioritization of safety goals in distributed teams at the Norwegian Continental Shelf.* Paper presented at the 17th Congress of the International Ergonomics Association, August 9-14, 2009, Beijing, China.

Skjerve, A. B., Sarshar, S., Rindahl, G., Braseth, A. O., Randem, H. O., Fallmyr, O., Sand, T., & Tveiten, C. (2011). *The integrated operations maintenance and modification planner (IO-MAP). The first usability evaluation – Study and first findings*. Center for Integrated Operations in the Petroleum Industry IO Center Program 4: Report no: IFE/HR/F-2011/1491, Halden, Norway: Institutt for energitekk.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, *19*, 387–420. doi:10.1177/030631289019003001

Storey, N. (1996). *Safety-critical computer systems*. Harlow, UK: Pearson Education Limited.

Wickens, C. D. (1992). *Engineering psychology and human performance* (2nd ed.). New York, NY: HarperCollins.

ENDNOTE

[1] In some respects the graphical representations of the jobs and the associated hazards (if any) might be perceived as en entity constituting a boundary object (Star and Griesemer, 1989). Onshore planners and staff offshore may use the representations different, but still the representations would most likely be sufficiently robust to hold a common identify across the various communities involved in the operational activity.

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Section 4
Cases

Chapter 13
Baker Hughes IO and BEACON with a Focus on Downsizing Personnel Requirements at Rig-Site

Joanna Karin Grov Fraser
Baker Hughes, Norway

Jan Ove Dagestad
Baker Hughes, Norway

Barry L. Jones
Baker Hughes, Norway

ABSTRACT

For more than a decade, Baker Hughes has developed a number of IO applications and WellLink technologies building its BEACON (Baker Expert Advisory Centre Operation Network) platform for the digital oilfield. The scope of BEACON is remote access of real-time rig data, drilling data and wireline data, production and pump monitoring, and static file management. These technologies have enabled the company's collaboration centers around the world primarily to monitor, support, and optimize operations without having to be physically present at rig site. This development has been a foundation for a successful roll-out of remote collaboration and re-manning of operations, where Baker Hughes has reduced the number of personnel needed at rig site by 25-50%. Monitoring and remote supervision of real-time information 24/7 to optimize overall performance and paperwork (logging, petrophysical analyses) are now all done by people in the office using information communications technology to connect to the rig site. Larger-scale re-manning can also be done with services such as reservoir navigation, drilling optimization, pump management, liner hanger down hole technical support, et cetera. On the Norwegian shelf, where re-manning has been done at higher levels than in many other regions, nearly 50% of Baker Hughes' staff who would traditionally have been offshore can be re-manned during operational peaks – this means they are either in an office onshore, or their responsibilities have been changed. Baker Hughes' cross-training of personnel facilitates this flexibility, allowing for efficient and HSE-compliant re-manning.

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INTRODUCTION

To achieve re-manning, a multitude of tasks has to be mapped out, defining roles to identify duplication and to best determine which could be shared, which could be moved to an office and which are not needed anymore for a specific project. Re-manning has also allowed the company to use the same head count for more jobs and with a larger global footprint, driving personnel efficiency to operations. For example in the Middle East there was no expert available in country to support the deployment of new technology at the time, but instead of turning the job down or to proceed at a high risk, a call went to our collaboration centers in Europe, where engineers were available to run the service remotely from the UK.

In 2006, the company kicked off 24/7 operational technical support for the Drilling & Evaluation services in Norway. Since then, this service has been expanded across Europe, Russia, Latin America and the Caspian region and is now being launched for Asia Pacific and the Middle East. "In traditional organizations, we often rely on our social network for support and technical support. It's only as good as the buddy that you know to 'call'. The 24/7 tech support centers formalize that network so everyone knows there is someone somewhere they can call for help at any time of the day, a step change in lowering the overall risk exposure and potential NPT.

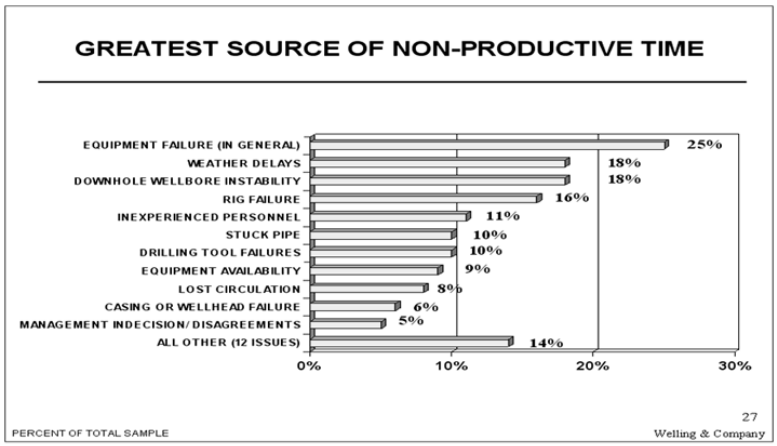
The E&P industry has been and still can be a lucrative business environment, but has been exposed to increasing risks, such as harder-to-reach reserves, high HSE exposure, Non-Productive Time (NPT) & drilling operation costs and scarcity of expertise, all driving costs upwards.

Figure 1 highlights key sources driving Non-Productive Time ref - 2009 report from a Welling & Company survey of 259 key decision-makers within oil and gas operating companies around the world engaged in drilling wells and utilizing drilling equipment and services.

There has been established a common understanding and belief that Integrated Operations will be an efficient enabler reducing overall risk exposure as well as to promote efficiency to operations.

Rapid development in IT capabilities have supported this understanding and been a significant contributor in the process promoting IO, providing data standards, more efficient data aggregation and integration solutions, applications developed utilizing standards and rapid growth in data volumes.

Figure 1. Sources driving non-productive time (NPT)



In Baker Hughes the deployment of BEACON is based on this believe and the objectives are to improve overall performance in drilling, logging, completion and production services, and by linking experts, resources and systems through a standard technology and process infrastructure to operations at the point of service delivery the infrastructure will enable 24/7 remote witnessing & support of operations, remote control, automation and data management services.

Already early 2000 Baker Hughes established BEACON, a service which allows office-based technical experts to monitor and control the real-time performance of remote drilling operations and assist on critical well applications.

At the BEACON center, Baker Hughes experts analyze live data streams from multiple remote projects. Using this data, engineers provide proactive advice and suggestions to support rig site personnel optimize efficiency and overall performance.

Through the process of sharing data and using common application systems, BEACON experts are able to include operator staff in the data evaluation — further increasing the "Team IQ" and enhancing the decision making process.

THE BEACON PLATFORM: A BASIS FOR THE ROLL-OUT OF IO

Since the mid-1990's Baker Hughes has been at the forefront of collaborative performance optimization initiatives, developing down hole tools to monitor and diagnose drilling dysfunction, powerful engineering applications for both predictive planning and modeling, allowing responsive reaction in real-time.

A major obstacle to facilitate seamless exchange of data, and consequently efficiency, is incompatibility between proprietary data formats. Baker Hughes has always supported and actively championed the use of open industry standards to promote free sharing of data. In this capacity, Baker Hughes took an active part of the multi-company teams that developed DART (Data Acquisition Real Time), which later evolved into WITSML.

With the BEACON platform the aim is to make optimal use of internal and external client expertise by facilitating the access of critical data sets for expert resources regardless of physical location or time zone constraints. During the course of drilling a well, specific competency may only be required for a limited period – and by providing technical experts access to critical data sets independent of physical location, operational performance can be improved without the requirement to dedicate expensive resources to a specific operation.

The key building blocks of the BEACON platform today consists of a fully redundant global infrastructure that consists of Data Centers, Data hosting, Rig Communication, Real-time data aggregation and distribution, Management of static files and distribution, WITSML Service Applications and a network of Operational BEACON centers.

The key objective is to improve the manner in which Baker Hughes can deliver Best-in-Class services to our customers globally with less constrains to infrastructure and logistic challenges. Recent rapid development in Information Communication Technology (ICT) promotes the process transferring large amounts of data between remote well sites and onshore facilities and vice versa. These transfers usually consist of real time and batch data sent via satellite communications or other rig-shore communication systems (e.g. microwave or fiber optic links) that may be in place.

Today Baker Hughes provides support for deepwater, shelf and land operations worldwide from any of its global BEACON centers in USA (15), Europe (5), Latin America (2), Africa (6), Saudi (2), Russia & Caspian (2). Within these centers, experienced engineers oversee daily operations, monitor data for high quality, monitor pore pressure, optimize drilling, navigate reservoirs, and provide a first point of contact for technical support and data distribution or entitlements.

This allows the BEACON infrastructure to act as a center of excellence that can help in interpretation or problem solving. By working with the rig site and shore based groups to enhance collaborative decision making, we can achieve the goal of increasing the Team IQ for well site operations.

THE BEACON PLATFORM: A BASIS FOR REMOTE OPERATIONS

The BEACON platform development facilitates a new way of working at the rig and in the process rig-office. A key element is to establish both efficiency improved performance and as part of this the strategy focuses on standardization of job functions and work tasks, with the aim to transfer work tasks from the field to the BEACON operations centre in a controlled manner. As an example, remote M/LWD (Measurement/Logging while Drilling) and remote Surface Logging Systems (SLS or mudlogging) have been established globally as a standardized remote service delivery anywhere required.

The service model is global and cross-training programs the same. This way Baker Hughes can ensure delivery of high level of services, reduced foot print at rig site, highly competent x-trained personnel, reduced cost and risk, as well as a high degree of learning and knowledge sharing.

Over the years there have been several alternative set ups of remote services, where remote M/LWD has been the most efficient solution. Remote SLS (or mud logging) has also been a part of the concept, with varying levels of manning on- and offshore. Several other custom made solutions have also been active for shorter or longer periods.

Due to the diversity it is costly and difficult to sustain all the different models over time and in order to capture practices and lessons learned, more streamlined solutions are required going forward.

In Baker Hughes we have therefore standardized our offerings for remote operations globally, based on extended experiences gained over the past 10 years, which have proven their efficiency and value for several customers and rigs/platforms/wells.

RE-MANNING AND REMOTE OPERATIONS SUPPORT FOR MORE THAN A DECADE IN NORWAY

Background: Prior to BEACON

We need to go back to late 1990's, when Baker Hughes in Norway began looking into the possibilities and opportunities of reducing personnel present at the rig-site, and at the same time being able to deliver the required and expected high service quality level to customers.

It was not only Baker Hughes initiating these thoughts and ideas. At the time, the customer was highly involved and encouraging Baker Hughes to challenge the traditional work tasks and processes within our services, particularly focusing on the possibilities of de-manning personnel from the rigsite.

In 2000 a roll-out was attempted to remove the MWD and Data Operator from the rig site and place them on land in a center in the Baker Hughes offices. The job tasks remained mostly the same and the technology was in place in order to successfully implement these remote positions.

For all the effort of completing this new method of delivering our services, we did not manage to increase our service quality. The concept was not sustainable, mostly because of lack of efficiency and by this driving direct cost. The objectives have always been to improve performance as well as to downsize personnel at the rigsite.

Though this concept was cancelled and had to be revised, it was clear that we had embarked on the correct path and that the future would definitely involve remote operations.

Objectives for the Revised BEACON Center Delivery Model

Early 2004, Baker Hughes deployed the new BEACON center concept. During this stage, Baker Hughes had to improve both financial and operational performance, and therefore new initiatives to achieve this were enforced. There was a strong willingness to change the overall operational organization with an aim to move job tasks, not positions which was first attempted. The goal for the new concept was to create new cross-trained jobs both at the rigsite and in the Remote Operations Centre.

A process was set up involving mapping of key personnel, discussing pro & cons with BEACON and offshore engineers and suggestions for improvements and feedback were captured and reviewed.

The overall conclusion at the time was that there was potential high resistance and uncertainty amongst affected Baker Hughes employees and thus further work had to be done in order to obtain secure optimal processes and buy-in from all staff involved..

Following this process, a BEACON pilot project was successfully completed on one well. All lessons learnt from the process prior to the pilot project and during the pilot well were taken into account and implemented as we went forward. This enabled Baker Hughes to optimize the overall internal implementation process of the BEACON concept and to promote positive engagement from all involved personnel.

Key defined goals and objectives that were highlighted in order to continue the process in establishing the BEACON 24/7 concept, included:

- Increase deliveries with a high quality at no additional cost.
- Implement efficient work processes and utilize synergies where possible.
- Enforce BEACON as "Best in Class" concept in remote operations.
- Increase focus on reliability.
- Effective competence and resource utilization.
- Possibility to introduce and perform specialized services from the center.
- Further integration between BEACON 24/7 and rigsite personnel and support personnel working 8-16.

The overall target has always been to improve reliability and quality, which would entail more sales and incremental revenue, at no additional cost.

Organization, Redefined Roles, and Responsibilities

The traditional LWD/MWD Engineer and Data Operator positions offshore were redefined and adjusted in order to be able to minimize personnel working at the rig site. The two positions offshore merged to one at the rig site and created a new position based in the remote BEACON center onshore; BEACON GeoScience.

The ARTE (Advantage Real-time Engineer) offshore kept the responsibility of the traditional Data Operator regarding well control, but all reporting tasks were transferred to the GeoScience Engineer sitting in the center onshore. Advantage in the definition refers to the Baker Hughes "Advantage" data acquisition system. In addition to well control, the ARTE offshore is in charge of the LWD/MWD realtime data stream, but all realtime and memory QC of geological formation data and data deliverables is conducted by the GeoScience Engineer in the center.

The various tasks of the two traditional offshore positions have in essence been split in two:

- Real-time and practical hands-on job tasks (ARTE - Offshore)
- Offline and more analytical job tasks (BEACON GeoScience - On land in BEACON center)

Separating these functions between practical and analytical tasks, gives everyone a unique opportunity to place the right person in the correct position within the company. The offshore ARTE position involves practical hands-on job tasks while the GeoScience position in the center appeals to staff with a more analytical ability and competence to evaluate data in more detail.

In order to achieve this, a considerable amount of training is required. An experienced Data Operator requires up to 5 weeks of classroom training and 28 days with On the Job Training (OJT) before being able to work as an ARTE. An experienced MWD Engineer requires 7weeks of classroom training and 28 days OJT.

In Norway today, there are a large dedicated group of engineers working within the onshore Baker Hughes 24/7 IO center. This is close to 25% of Baker Hughes total offshore Drilling & Evaluation operations staff. In addition nearly 70% of all offshore Drilling & Evaluation operations personnel are cross trained for fit to purpose job responsibilities in order to be able to provide our services benefiting from the BEACON concept. They are all offshore based and have offshore contracts, but as a result of their cross training, they are also able to assist by working temporarily in the 24/7 center.

Thus we have established a very versatile and flexible staff that can work where they are required.

Today there are three main services based in the BEACON 24/7 center in Norway today:

- GeoScience
- Drilling Optimization Services
- Operational Downhole and Surface Technical Support

The BEACON GeoScience engineers QC all logged formation evaluation data, produce real time and memory deliverables following standard operating procedures and distribute these files daily to the customer.

The BEACON GeoScience service may be provided at different levels. The higher end includes realtime Geosteering. Whilst there is a RNS (Reservoir Navigation Service) supervisor who has the main responsibility for the Baker Hughes total RNS services provided for each well, the BEACON GeoScience engineers support this service out of normal working hours. Thus we are able to provide RNS 24/7 from onshore.

The service involves monitoring and adjusting the position of the well path in response to formation evaluation data to reach one or more geological targets. This will maximize short and long term production, reducing drilling risks and costs. Being able to provide this service 24/7 is imperative for the operation and provides high value to the customer.

Although Baker Hughes Geosteering service (RNS) was introduced more recently compared to LWD/MWD and Mudlogging services, it did require an additional engineer present at the rigsite in order to deliver a 24/7 Geosteering service. By training the BEACON GeoScience engineers to complete this task, we have again reduced the number of personnel at the rigsite.

In 2006 the second service was introduced from the BEACON center, the 24/7 Drilling Optimisation service. This service can also be provided at several different levels and the higher and advanced services involve high impact recommendations.

Drilling Optimization is in general a service given to improve drilling performance, focusing on borehole quality, progress rates and time consumption during drilling. The Baker Hughes drilling optimization tool (CoPilot) measures downhole dynamics and mechanics and enables the Drilling Optimisation Engineer to use this data together with other LWD/MWD data to identify and resolve harmful drilling dysfunctions thereby allowing drilling to continue at maximum efficiency and safe rates of penetration.

This service was introduced offshore in mid 90s and because of the high demand for the service, it was necessary to introduce it to the BEACON center. Providing the service from land again reduced the need for an additional engineer present at the rigsite.

The technology within LWD/MWD has developed and escalated at an extremely high pace over the last decade and the need to have a team of experts to support all operations was a necessary progression to lower the risk exposure. The third BEACON 24/7 service involved operational downhole and surface technical support. A technical support team was established late 2006 and working from the BEACON center they not only support all BEACON de-manned rigs, but also all Baker Hughes jobs in the North Sea.

The technical support service is a supplement to the BEACON center team and does not entail any rig de-manning but will lower the total risk-exposure and has a proven record of increased quality.

This service was founded as a catalyst for maintaining and aiming to increase Baker Hughes overall reliability and performance within all Drilling & Evaluation operations. The service has been an invaluable addition to the BEACON center.

Total Reduction of Offshore Personnel at Rig-Site

By creating these positions mentioned above, the model reveals a reduction in personnel at the rigsite.

Baker Hughes traditional manning at rigsite for an LWD/MWD operation included (during 24hrs):

- 2xDirectioanl Driller
- 2xLWD/MWD
- 2xDataoperator
- 2xMud Logger
- 1xRPS (Radiation Protection Supervisor)
- 1xFE Specialist (Additional support for specialized or non-standard high tech tools)
- 1xCoPilot (Drilling Optimization Engineer)

Rigsite manning with BEACON solution 2011has allowed a reduction of 4 personnel offshoe – a massive 37% reduction – per rig.

A total of 4 positions are de-manned from the rig site with the use of the current BEACON concept. In addition to Baker Hughes objective to deliver Best-in-Class in terms of overall performance, quality and reliability, the customers in the North Sea also see the vast potential of rig de-manning.

The industry is focusing on reducing personnel at the rigsite by applying various IO alternatives, in order to reduce HSE potential hazards, but at the same time it must not jeopardize the quality and performance of the service at hand.

Today mapping of work tasks vs. responsibilities has been done in details prior to established standards, and builds on learning's and methodology captured for the Oseberg East project and the phase 2 drilling campaign. A key finding was the development of a cross-training matrix that was based on a holistic approach to 'manning by tasks' rather than 'manning by services'. The cross-training program transgresses internal company product lines and, radically, company boundaries (reference to SPE/IADC SPE-105065-PP).

Benefits Experienced with BEACON IO Center in Norway

Minimize HSE Exposure

All operations at the rigsite introduce a more hazardous working environment than an office based work area based on land. Therefore minimizing the personnel present at the rigiste when possible is desirable for all parties involved.

Increase Quality

Over the years, Baker Hughes and BEACON have received positive feedback from our customers regarding the quality of our service. As an example, the BEACON GeoScience service produces increased high quality LWD/MWD deliverables, which the customer acknowledges.

Reliability as measured internally, and also independently by our customers, has showed very positive trends as a result of the increased and improved technical support offered through our BEACON centres.

A key driver for this success is standard operating procedures for all rigs, and the 24/7 availability of technical support

Increase Work Exposure

Working in an IO center, an engineer is more exposed to continuous operations compared to being onboard at the rigsite. The Baker Hughes IO center supports up to 11 rigs (not including technical support, since they support all Baker Hughes activity in the North Sea) thus there will always be activity to be exposed to. Working on one rig only, engineers may experience little variance in work tasks, operations complexity, or high volume work exposure for various reasons regarding the specific rig operations.

In the BEACON center, the standard procedures and daily documents for all rigs enable engineers to work on several rigs, depending on the workload and activity.

Increased Possibilities for Training

Engineers training and working in the BEACON center have the opportunity to become both competent and experienced with some of the work tasks at a much earlier stage then working on the rigsite.

Again this is due to the more constant work exposure which is available and possible in the BEACON center.

Staff Utilization

The utilization of personnel working within the BEACON center is very efficient due to that they are able to perform multitasking operations, supporting operations on multiple wells.

Experience Transfer and Synergies

An IO center, such as BEACON enables all engineers working at all times to share their knowledge and experience in a more efficient and practical manner.

Considering that one engineer will likely be working on more than one rig during a working day, the engineer will be communicating with other engineers on the same shift in addition to engineers on opposite shifts, utilizing individual rig handovers and common handovers.

HSE Benefits

Though it is debatable, the majority of the engineers see the potential in being able to work shift on land and not work at the rigsite. It is possible to maintain a structured and continuous contact with family relations and spare time occupations, which would not be possible with an offshore working rotation which entails working at the rigsite for two weeks at a time.

All 24/7 work operations involve working night shift, it is therefore debatable to state this as a benefit. One can also argue if working nightshift on a rigsite is more effortless than working on land.

Collaborative Environment

The BEACON center is the heart of a collaborative environment where other disciplines are located as close as possible to the 24/7 IO center. All office positions in Operation Planning and Support, such as Technical Support, Application Engineering, Reliability and Maintenance, GeoScience and

RNS Supervisors are all functions that communicate on a daily basis with BEACON 24/7 staff.

This enables efficient communication between the disciplines and BEACON and empowers the ability to produce quick answers based on teamwork and expert advice.

Such an environment aids Baker Hughes to deliver Best-in-Class services to the customer.

Challenges and Issues Experienced with BEACON IO Center in Norway

Monotonous Work

Working in such an environment will to an extent entail some degree of repetitive work tasks. It has been mentioned earlier, that standard procedures are a key element that need to be in place and adhered to continuously. This is necessary to drive efficiency in order for the services provided by the BEACON center to be successful and with Baker Hughes' high quality expectation level. However, the continuous exposure to multiple rigs and wells alleviates the monotony and offers accelerated learning as compared to Offshore work.

Working Schedule

Ideally, it would be beneficial to constantly rotate offshore and BEACON 24/7 staff. Transfer of experience and knowledge, communication and collaboration between the two groups would increase by establishing such a combination. But due to Norwegian working laws and union agreements, this is currently not a long term sustainable option.

Meantime, all personnel working on land in the 24/7 center need to follow an alternative fixed schedule that has been specially designed for staff working on land in the BEACON center.

The huge practical pit fall with this schedule is that it only opens up for engineers living in close distance to the center.

Thus acquiring experienced staff is a challenge, considering traditionally that offshore engineers in general, have not had any restriction regarding where they live in Norway.

Challenges and Issues Experienced with BEACON IO Center Globally

The issue regarding the working schedule applies mostly to operations in Norway. The other challenges mentioned will to some extent also apply to all Baker Hughes centers globally. Though, due to the varying size of the centers outside Norway, they are not necessarily major concerns.

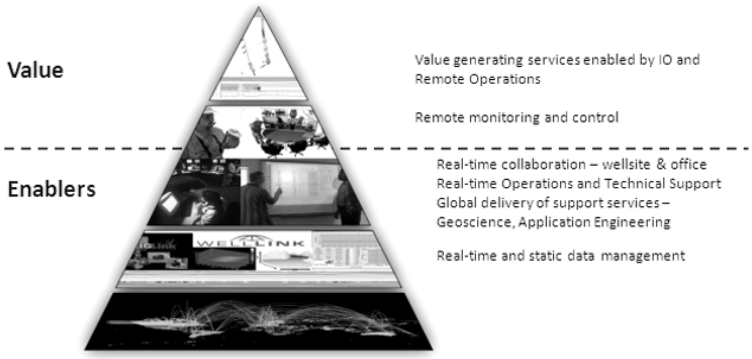
The set up of the numerous IO centers worldwide have several different solutions and the capacity and complexity of the services vary from what the BEACON center in Norway provides. One common challenge that centers outside of Norway may experience is connectivity issues. To be able to efficiently remote operate workstations, a stable and reliable network is necessary. In Norway there are no major issues related to this as almost all offshore installations have sufficient high speed network, based on fiber and radio links connected to the rigsite and additional built in redundancy. Other Baker Hughes IO centers may rely on satellite transmission with a less robust and slower connectivity infrastructure. This does not always provide a constant and steady data line and latency issues will occur when remote operating work stations at a rigsite in some areas.

Another challenge experienced globally is related to the weather. Tropical storms have shutdown IO centers that are located in areas affected by such extreme weather conditions. To be able to deploy IO globally infrastructure is a key enabler, and today Baker Hughes has a program to deploy a standardized Remote Operations platform to most of its locations globally.

This includes building a resilient and secure IT network infrastructure for data, voice and video to enable real-time information sharing, remote monitoring and control services, remote support and expert advisory services and interactive collaboration services.

The BEACON pyramid, illustrated in Figure 2 provides a graphic overview of the building blocks for the Remote Operations platform.

Figure 2. BEACON platform pyramid



Solutions and Recommendations

Norway Operations

Repetitive work is to an extent unavoidable in an environment that requires staff to accurately adhere to standard procedures and checklists on an hourly and daily basis. To minimize this potentially negative motivation factor, Baker Hughes has the engineers cross-trained to other disciplines within the center. This keeps the engineers motivated and they gain a wide knowledge and expertise within the different services that the IO center provides.

When the engineers work regular working hours during the weekdays, they are also involved in other work tasks and responsibilities together with the 8-16 regular office staff. This again benefits by strengthening the collaborative environment within 24/7 personnel and personnel working regular office hours.

Regarding any practical issues that may arise when customers have different requirements for their IO solutions, Baker Hughes has established a flexible work staff due to the comprehensive cross training. Baker Hughes is therefore able to provide multiple options to the various customers in order to comply with the individual customer expectations.

Acquiring and attaining experienced personnel in the BEACON 24/7 center has its challenges. Not only due to that the schedule restricts employing personnel not living in close distance to the 24/7 center, but there is also another aspect regarding that the BEACON center produces engineers who become experts within their field. If a competent BEACON engineer in addition seeks work involving regular working hours 8-16, then the engineer becomes exceedingly attractive in the employment market. Baker Hughes therefore focuses on individual personal development and encourages employees to keep challenging themselves, whether that be cross-training within another discipline in the BEACON 24/7 center or by transferring them and offering 8-16 positions, where the expertise is required. This enables other departments in Baker Hughes to benefit from their expertise and it is also advantageous for the individual with regards to further personal growth within Baker Hughes.

Today the BEACON center strives to maintain a healthy balance between personnel that have previously worked offshore for Baker Hughes (or in other drilling related positions for external companies) and graduates and engineers with less offshore experience.

Baker Hughes Globally

Any major change to a work process, needs to be carefully assessed and tested prior to attempting a roll-out of new procedures and work tasks. Risk

Assessments and similar risk management systems need to be completed in order to evaluate the risk at hand and enable mitigation of potential risks with sustainable solutions.

Risk Assessments are important tools to identify a risk that might not have been an issue in the first place. Baker Hughes has prior to the launch of the BEACON remote operations concepts completed such Risk Assessments. For the operations in Norway, this consisted of altering, adding and creating new work tasks to the existing engineers work tasks that were assessed. In other 24/7 center outside of Norway, for example in Brazil and Macae, issues such as the weather need particular planning and attention.

In a situation where the power could potentially shutdown or staff would not be able to get to the workplace due to severe weather conditions, several contingency plans had to be in place. Backup generators, relocation of 24/7 staff to other IO centers and temporary relocation of the work tasks to other 24/7 centers were some of the mitigation plans in such an event. The BEACON center in Norway, or other global BEACON centers for that matter, can function as a substitute center for Macae under such circumstances. This can be done for a given time frame and by doing so establish redundancy. Experience transfer between the centers is imperative to enable reinforcement of Baker Hughes global standards. As mentioned, all centers produce and deliver various different services to meet the customers' requirements. In order to enable the different centers to develop the most effective and productive IO centers, providing Baker Hughes Best-In-Class level of performance and quality a reasonable amount of collaboration between the centers has taken place.

As an example, experienced engineers from the BEACON center and the rigsite in Norway, have worked in the 24/7 center in Macae and on the rigsite in Brasil, in order to provide effective on the job training (OJT) of Baker Hughes colleagues training to work in the BEACON 24/7 center in Brazil.

Other collaborations with global 24/7 centers have involved experienced Reservoir Navigation Service (RNS) engineers from the BEACON center in Norway working in smaller centers outside of Norway by providing OJT to less experienced RNS engineers.

Such transfer of experience from the BEACON center in Norway to other centers being established worldwide, enables not only the possibility of providing global standard for Baker Hughes IO centers, but emphasizes the ability of one center to act as backup for other centers and to reduce the risk exposure by building in a service redundancy.

FUTURE DIRECTION FOR THE BEACON CENTER IN STAVANGER

The BEACON center in Norway is currently being built in new locations in Tananger, Stavanger and will be considerably larger than what it is today. Plans and discussions for the future are ongoing, but there is no doubt that the future for the BEACON center in Norway involves growth.

Other services that have only been introduced from the center on a small scale will be developing in the near future. Coil Tubing Drilling, Completion and Production, Integrated Pore Pressure Services and Pressure Pumping are all services that will be developed and introduced from the BEACON center. Whether it will involve demanning or additional support to the rig operations or a combination, will need to be assessed through Risk Assessments.

Looking forward, the BEACON center in Norway will also provide more and intense in-house OJT for colleagues from abroad. For practical reasons, it is not always viable to send engineers abroad. Providing a colleague from abroad with OJT in the center in Norway is more effective, considering the amount of operations and services the center in Norway provides.

It is also very likely that the future will involve the introduction and development of more

automated operations at the rigsite. This would involve further possibilities to transfer work tasks to IO centers such as BEACON.

CONCLUSION

IO and BEACON enforce major organizational changes both offshore and onshore. The process which initiates large scale challenges to well-established and traditional work tasks, needs key parameters to be in place before and during the process, if it is going to be a success.

- Good communication between all parties involved.
- Management involvement.
- Involvement and cooperation of all parties.
- Incentives.
- Motivated personnel.

The quality of this process is highly dependent on management and union involvement and actions, which again will have a high impact on the employee's willingness to change.

Closer relations between the offshore and onshore segments have also been developed through this process. These two large groups within Baker Hughes have benefited from the implementation of the BEACON concept by enabling closer collaboration and increased communication between these two relatively large organizations.

Considering that the concept is now highly integrated into the entire organization, it is legitimate to say that the concept is here to stay. It is not a question of undoing what has been created and established, but only developing and improving the idea.

The concept has created a solid foundation for future development within IO for other divisions in Baker Hughes. There is an industry expectation that Baker Hughes will develop the concept, not only towards other services within Baker Hughes, but also to further develop de-manning solutions within drilling operations.

The objectives Baker Hughes set out to achieve when launching the BEACON 24/7 center including the new cross trained positions offshore and onshore, have been met. Some can be ticked off as successfully accomplished, some were more challenging and a few only partly achieved. The quality and standard of the deliverables has increased and there are efficient standardized procedures in place.

Most important, several of the objectives and goals cannot be put aside though they have been completed. It is important to preserve these key factors and strive to successfully relate to them on a daily basis. The foundation and the achievements reached so far are embedded in these vital key elements.

IO and BEACON is more of a journey, with key milestones to be accomplished being able to reach the next level. It is a process driven by both technology and the organizations learning capabilities.

REFERENCES

Dagestad, J. O., Saeverhagen, E., Nathan, E., Knutsen, S., & Norsk Hydro. (Amsterdam 2007). *Multi-skilling as a key factor for economically viable operations in a mature oil province: Oseberg East as a case example.*

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Chapter 14
Integrated Operations in Petrobras:
A Bridge to Pre-Salt Achievements

Claudio Benevenuto de Campos Lima
Petrobras, Brazil

José Adilson Tenório Gomes
Petrobras, Brazil

ABSTRACT

Known as an integrated energy company that operates in all segments of the oil industry, Petrobras has a broad management experience and uses a multidisciplinary approach, which applies to different areas. Recently, the impressive discoveries of the Pre-Salt reserves have created an exciting scenario in multiple aspects. Petrobras expects to produce more than 5 million bpd of oil by 2020, out of which only 1 million will come from Pre-Salt. This leads to an approach that will require scalable and sustainable solutions that take into account the better understanding of how people, processes, technology, and governance issues are connected and managed (Hendserson, J. et al., in this book). Considering past experiences and the complexity of the new oil and gas production scenario, Petrobras is preparing an even greater leap in its upstream operation and maintenance management systems – a corporate initiative called GIOp (acronym for Integrated Operations Management, in Portuguese) is being implemented. This chapter describes the implementation of GIOp in all upstream operational units of Petrobras in Brazil, considering the main organizational aspects, the methodology to develop a portfolio of opportunities, the scalability of the solutions, and the initial experience in Pre-Salt production.

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INTRODUCTION

The first experiences with upstream Integrated Operations in Petrobras took place during the last ten years, focusing initially on drilling centers. Some 3D visualization rooms were implemented. Also at this early stage, one specific center was put on operation in Brazil dedicated to turbo machinery condition based maintenance, providing the surveillance of equipments installed on Petrobras offshore platforms. Later on, the implementation of a systematic approach to redesign processes was promoted in production assets. Pilots were setup, addressing different scenarios of production in Brazil. Thus, many lessons learned came up for future initiatives.

The Integrated Operations in Petrobras is referred as GIOp. It is defined as the integration of disciplines, service companies and the organization, combined with data in the relevant time, considering the redesign of work processes, in order to have better decisions and more efficiency, using collaborative environments. The main focus is to be proactive instead of reactive, forecasting situations before they become critical and identifying opportunities to gain and improve these processes.

The impressive discoveries in the Pre-Salt have created an exciting reality in multiple aspects. Petrobras is the operator of almost all blocks of this new exploratory frontier. In order to more than double the current proven Brazilian reserves in the next decade, big challenges must be faced, like the distance to the coast, water depth and the complexity of the reservoir. In 2020, Petrobras plans consider an oil production of more than 1 million bpd from Pre-Salt reserves. The new scenario will demand a relevant change in the management of the main processes. Formigli-Filho et al. (2009) states that: "The successful development of the Santos Basin Pre-Salt will be a hallmark for Petrobras and its partners, contributing for the oil industry development, particularly in Brazil."

GIOp is dedicated to enhance collaboration across the relevant processes. An implementation strategy has been carried out in all Petrobras E&P Operation Units with significant importance in the greenfields of the Santos Basin, province where most of the reserves of Pre-Salt are located. Special attention was dedicated to set the objectives and drivers. The opportunities of GIOp in Pre-Salt were analyzed through an intensive assessment. In order to help the methodology of redesigning processes, a pilot of application is already running in temporary environments considering the existing facilities (rigs and production units) in Santos Basin.

The development of the Pre-Salt Layer in the Santos Basin involves overcoming challenges related to reservoir characteristics, water depth, and logistical issues associated with the distance of the greenfields in relation to coast. Thus, the optimization and integration of certain processes is essential to reduce operational and investment costs in order to ensure higher economic return.

GIOp will allow an increase in operational safety activities in the Santos Basin, as it is based in a better control and monitoring of the facilities and processes, from collaborative environments, minimizing the transportation of people, equipment and materials in huge distances. In that sense, a systemic view of operations will be provided to deploy the demanded infrastructure and also the solutions to operational problems in order to enhance of production and operational efficiency and lower CAPEX and OPEX.

The implementation of GIOp across Petrobras units will be described from the past history cases of smart fields, considering the main aspects of the Petrobras organization, the methodology used to develop a portfolio of Integrated Operations opportunities, the scalability of the solutions and the early results.

In this chapter, the experience of Integrated Operations in Petrobras is described to provide a practical approach of the industry in a different cultural scenario rather then the Norwegian

perspectives. The description will be developed based on the past experience of Petrobras, related to model management changes, process monitoring and control, development of capabilities in Integrated Operations, operation of drilling centers and the emerging experience of condition-based maintenance applied to rotating equipments. After, the way that new challenges refer to a cultural change management to meet new realities will be reported. Based on this background and considering the new implementations that are been deployed at Petrobras, it is possible to see a clear connection between GIOp methodology and the main theme of this book - Capability (See Figure 3, Hendserson, J. et al, in this book).

PAST EXPERIENCES IN PETROBRAS

Internationally, Petrobras is known as an integrated energy company that operates in all oil industry segments. The company has around 60 years of activities that allowed a broad management experience, flexible and multidisciplinary approach, which applies to different areas of the supply chain sector.

The knowledge through the onshore oil production, initiated in the 50s, enabled the first steps of Petrobras to explore the shallow waters of the Brazilian continental shelf, between 1960 and 80. Such a successful experience promoted a shift in the trajectory of the company. From the 90s, Petrobras has taken the place of the main international reference in the technology of exploration and production of oil and gas in deep waters.

In the following topics, the key initiatives and changes will be summarized to give the context of how Petrobras was driven towards the path of integrated operations. Fundamental issues, such as organizational change, technological aspects regarding to the oil and gas production process monitoring and control, new technologies to improve the quality of the wells construction, reservoir behavior monitoring and also the critical equipment surveillance to ensure operational continuity are highlighted.

Business Operations, Operational Capabilities

As a result of the review of its management model and organizational structure in 2001, Petrobras implemented a new approach: the Organization based on Production Assets. Then, the Operations Managers were created in order to bring decision taken closer to operational front and give more flexibility to the process.

This organizational change was crucial for Petrobras to begin strengthening the governance across its processes. There is an interesting approach to process in Hendserson, J. *et al.* (in this book): "A process is a set of activities or work flow with a specific beginning, a well defined end point and a clear and measurable goal." This was essential in the construction of GIOp. Without this change, hardly a proper environment for the consideration of the aspects of people, processes, technology and governance would be developed in the future.

Analytics and Collaboration Capabilities

In order to guarantee permanent improvements in production operations, the company accelerated, after 1986, the incorporation of sensors to develop automation. Campos et al. (2006) argues that "There is a gap between automation and petroleum engineering that, when fulfilled, will help the technology absorption and continuous feedback." Artificial lift and production station automation started to take place on onshore fields in late 80's and early 90's. This improved monitoring activities and increased automatic controls.

In 2001, to help the understanding of complex systems in reservoir characterization of oil, the company installed a 3D visualization room in Rio

Grande do Norte and Ceará state assets (Northeast Brazil). The 3D reservoir modeling allows better quality and productivity in the studies and it is possible to consolidate data and create interpretations in a consistent geometric model by integrating the work of specialists from different disciplines. More 3D rooms were subsequently opened in other units.

Intelligent Infrastructure/ Foundational Capabilities

As part of the four key IO components based on the capability platform, the technology and all the infrastructure necessary for its implementation and proper use is fundamental. Following the technological world evolution and applying the best practices, Petrobras, since the beginning, has paid special attention to these issues.

Since 1991, in the Petrobras production region located in Sergipe and Alagoas states (Northeast Brazil), PLCs (Programmable Logic Controller) have been installed with automation systems, incorporating dedicated and smart transmitters in gas-lift installations and vessels at the production facilities. In 1998, the first supervisory was operating 40 onshore wells (Carmopolis Field).

In 1992, all the onshore plants of Canto do Amaro, Alto do Rodrigues and the Rio Grande do Norte state Fields have been automated. Two years later, the first injection of gas lift was automated to wells in Bahia production area and also in the same year the company put on production automated rod pumps in Canto do Amaro and started the activities of automation in the Amazon region. Based on this, it was possible in 1999 to operate separators and pumps of the East Urucu Field (uninhabited), using remote monitoring via radio link, in the middle of the Amazon jungle.

The first automated and unmanned platform (PUB-10) was installed offshore in the Ubarana Field, in Rio Grande do Norte state in 1996.

Another important step happened in 1998, with the introduction of fiber optics data transmission in Campos Basin. The company installed a submarine backbone integrating electric power and telecommunications in the Northeast Pole of Campos Basin. So, it was possible to interconnect the platforms of Pargo, Vermelho 1 and 2 and Carapeba 1, 2 and 3. The deployment of the electro-optics digital transmission technology was a significant achievement.

A 490 km optical ring went into operation, in the Campos Basin, in 1998. It began to be installed in 1995 and initially interconnected nine production platforms. Today, it serves the communication of 83 units, ensuring safer operations, reliable and real-time data for exploration and production of oil and gas.

In 2000, with the increasing volume of data, generated by activities on the platforms, Petrobras set up a technological base to enable secure and real-time operational information. It was the beginning of the implementation of PI (Plant Information), later spread through the rest of the company.

The Stepwise Development of Capabilities, Some Examples of Strategic Experiments in Petrobras

Monitoring of Fields in a Integrated Way

Given the growing interrelationship of many disciplines, Petrobras began implementing six smart field pilot projects in 2006 in order to integrate exploration and production processes and facilitate decision making. The scenarios were chosen based on location (onshore and offshore), maturity (brown and greenfields), lifting systems and service companies. The smart field implementation in Petrobras was called GeDIg (acronym to Digital Integrated Management, in Portuguese).

The main objective of these pilot projects was to evaluate different technologies and to improve the monitoring and control of daily operations of production, with an integrated view of the fields. "The multi-scenario pilot projects are represen-

tative sample of Petrobras production panel and allow the evaluation of technology application on different processes and workflows" (Moises et al., 2008).

In June 2007, the Operational Control Center (OCC) was installed in order to facilitate decisions on the management of production across the Campos Basin. This center also collaborates in the treatment of crises, emergencies and contingencies that affect the Units.

From September 2008, Remote Control Rooms (SCR) have been implemented in Campos Basin offices (located in Macae City). Today more then 10 offshore platforms are fully operated from onshore, ranging from simple to complex operations. The SCR enables interaction with other collaborative environments and also facilitate the decision-making and the immediate involvement of experts.

Drilling Centers

Drilling investments have a significant importance (around 50% of the total E&P investment). In order to involve experts located physically distant from the rig operation, from 2006, Petrobras started the implementation of Drilling Centers. So, it was possible to remotely monitor and model in real time, improving safety and lowering risks in drilling, completion and maintenance of wells and also to direct the well path to optimize production.

Moreover, many operations have been performed with efficiency in exploration using collaborative centers, like geosteering, monitoring with the geological model through the seismic cube, logging in real time, monitoring of samples of fluid and rock and determination of areas of interest for the production of hydrocarbons.

This new approach based on collaboration brought rig operations to a higher level of efficiency and reduced the time and costs of the interventions.

Condition Based Maintenance Applied to Rotary Equipments

In December 2006, a pilot project for Condition Based Maintenance was implemented in Campos Basin. The main objective was to monitor variables and parameters that indicate the performance of critical equipments in a systematic way. In that sense, it was possible to define the need for intervention in the rotary equipments (turbines, generators, compressors and pumps) in order to enhance the remaining life.

In September 2008, it was implemented in Campos Basin the Integrated Center for Monitoring Turbo machinery (CIM-TBM). This center applies diagnostic algorithms for automated multiple users to simultaneously evaluate the conditions of performance of turbo machinery. It also allows the implementation of preventive actions.

THE CHALENGES OF A NEW REALITY

Pre-Salt: The New Production Frontier

The Petrobras challenges in the years ahead will require a new approach to produce the Pre-Salt reservoir in an optimal way. The growth and complexity of activities that are revealed on the horizon are big, considering the production of the Pre-Salt. It will be mandatory to develop great opportunities in the coming years in areas onshore and offshore in order to achieve ambitious targets. The total daily production of oil and gas Petrobras in 2020 will be 5.7 million barrels of oil equivalent. Moreover, there is a commitment to increase reserves in a sustainable manner.

A New Work Philosophy

From now on, the focus must be concentrated on fundamental elements, which can be summarized

in four components: people, processes, technology and governance.

Focus on people is reflected in integrated and collaborative work, removing barriers between disciplines.

Focus on processes means to redesign and simplify the important workflows that are connected to the value chain. "Effectively identifying which and how processes must be adapted to the new way of working is one of the critical points for the project's success" (Derenzi et al., 2009). It is necessary to integrate disciplines, perform the planning onshore and adopt condition based maintenance. And not least, delegate tasks and empowerments must be considered in order to make smart decisions.

Focus on technology is to adopt innovative and not prescriptive solutions. It is fundamental to exercise three S approach: Scalability, Standardization and Sustainability. It is important to use as much as possible the existing technologies, in order to simplify and standardize solutions, keeping an eye on technological developments of partners, industry and academia.

The focus on governance is one of the most relevant in the process, as it gives the sense of ownership to the whole structure involved. Through a well-structured governance, in compliance with the management levels, people involved in, either during deployment or during follow-up, feel valued and perform their tasks with more motivation.

Seed and Green Fields: Where the Integrated Operations Must Start

The success of Integrated Operations can be credited to a strong organization and interaction of the teams involved in the operation. What was planned from the moment of discovery is decisive to the future of the field developments. In fact, integrated operations should be initiated very early at this point.

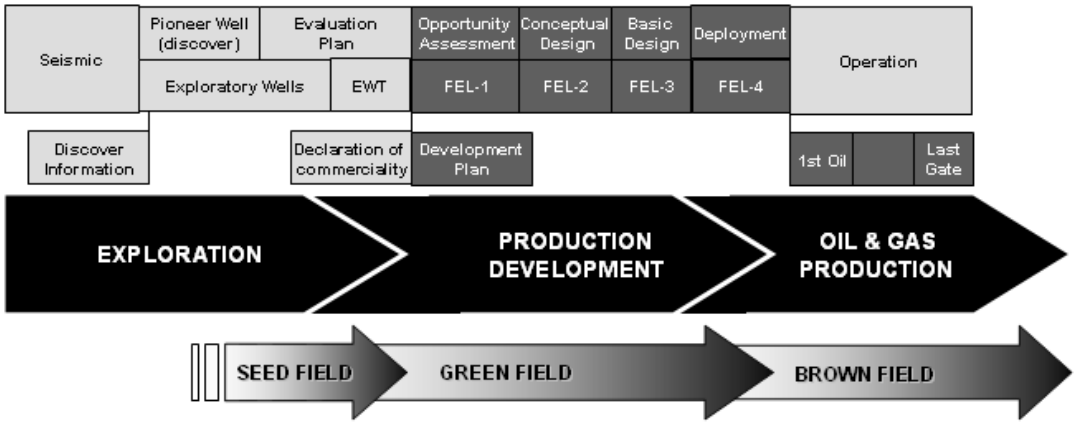
In the period between the notification of the discovery of a new oil accumulation by the exploratory team and the declaration of its commerciality, it is necessary to plan and execute actions in order to provide data acquisition. This will provide better reservoir understanding and delimitation. At this stage, it is essential to start structuring the future integrated operations.

This early period of life of the new concession is called "Seed Field". After well known and characterized, the field can represent an important economic asset to the company in terms of oil and gas production. Later, the exploitation will make this opportunity to become a reality. The production will begin in subsequent cycles of Green Field and later Brown Field, until the time of final abandonment.

In the Seed Field phase; before the declaration of commerciality, the application of the concepts of integrated operations should be initiated. In the first aspect, the main objective is the organization of the work, considering the involved teams. They must work, with their specific expertise areas, in an integrated way for better action planning to acquire the necessary information for the proper qualification of the new discovery. So, it is necessary to involve the exploration teams, which are responsible to propose and implement the new discovery evaluation plan and the engineering teams from reservoir and well construction, flow assurance, subsea facilities and support areas, to work in an integrated way to add value. At this point, some aspects are relevant to consider. For example, what should be the sequence of drilling exploratory wells, what kind of logs and formation evaluations should be performed, the geometry of the wells being drilled, the possibilities to use the wells for operation (production or injection).

The second aspect is related to the planning of the future integrated operations. At the stage of the recent discovery evaluation, it is recommended to start planning the facilities, equipments and surveillance that will allow integrated operations into future operations in an efficient level. In this sense, the application of all information generated during activities related to the commitments to

Figure 1. Maturity level and the value chain



the regulator entities should be maximized, such as the drilling of wells, adjacent and extension wells, seismic acquisition and processing, DSTs (Drill Stem Test), among others. These concerns are relevant not only for defining the purpose of declaration of commerciality, but also to accelerate the start of the development production plan and first oil anticipation.

The project design and development for the field start after the declaration of commerciality. At Petrobras, the implementation of projects is based on the concept of Front End Load (FEL). Each project must go through four phases: opportunity assessment, conceptual design, basic design and subsequent deployment to start of production. Green Field is the phase that comprehends the field lifetime to reach a volume recovered of approximately 50% of the total. After that, it is called Brown Field. To think and to act in an integrated way from the very early start of field life is the key of success for future operations. Figure 1 represents the level of maturity of the fields (seed, green and brown) in the value chain. These concepts will have a huge impact on the Pre-Salt implementations and on the application to an Integrated Operations case in Santos Basin as will be explained as following.

GIOp: A Little Bit on the Philosophy of the New Generation of Integrated Operations

In order to implement the Integrated Operations to cover projects in Petrobras upstream segment, GIOp was launched as a Strategic Initiative. The central pillar of this program is the integration of the operations of Exploration & Production.

The philosophy of GIOp is based on three different loops of action: fast, medium and long. A loop can be described as a task sequence that starts with the evidence that the workflow is in lower performance or can be optimized (an alarm or a tendency of a parameter, for instance). From this point forward, it starts the diagnosis, decision and implementation phases, than returning to the original point of the loop. A new indication may mean that the actions were successful or not. Figure 2 (a) represents a schematic view of a loop of actions.

The fast loop consists of experienced professionals who are able to solve the *quick wins*. Thus, the main characteristic of this loop is not to have diagnosis meetings, since decisions are based on the expertise of the fast loop professionals. In GIOp, usually, the fast loop consists of surveillance and it is responsible for monitoring and

optimization of certain workflows (production plants and wells, for example) and it can be considered like the "eyes and brains" of the body. The solution of *quick wins*, using this approach, will be fundamental in the Pre-Salt scenario, with huge well and platform productions.

The diagnosis meetings are mandatory in the medium and long loops, as per multiple disciplinary professionals from different parts of the organization are involved. If the decision is more operational, focused on immediate actions, it will be associated to the medium loop. The long loop will be related to strategic decisions connected to business and managerial involvement.

Figure 2 (b) represents the coupling all the loops in a single model, where the loops are arranged in layers, which are connected dynamically. This philosophical approach of GIOp is known as *onion*. In the skin, there are the managers involved in strategic decisions of the long loop.

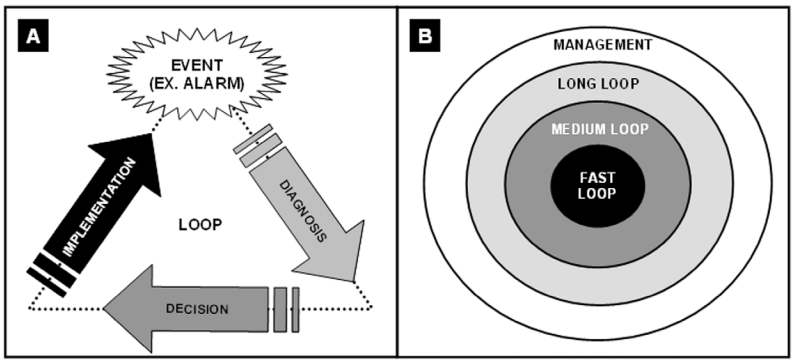
An important exercise of the philosophical model of GIOp is to keep the managers in the more external layer, since they strongly influence all sort of decisions. So, it is fundamental to have the correct information flow across the onion layers, in order to keep the managers involved in the decisions that are really demanded.

The First Steps of a Change: Divide it and Make Full

Considering the new discoveries of Petrobras in the Brazilian Pre-Salt, many complex aspects went to discussion and Petrobras will face many challenges through the whole upstream production chain: from reservoir to the logistics that will support all operational activities. The development of Pre-Salt in Santos Basin involves overcoming challenges related to logistic in an unexplored area without infra-structure, water depth, salt layer zone thickness, reservoir characteristics, scale and wax issues and a special production model along with partners. Thus, the optimization and integration of certain processes is essential to enable the implementation of important projects in Pre-Salt, by reducing operating and investment costs to ensure greater economic return.

Some important reservoir concerns could be pointed, like: the internal reservoir characterization, with focus on the main heterogeneities, the technical feasibility of Water Alternate Gas (WAG) injection, CO_2 injection performance, waterflood (wetability, heterogeneities), EOR strategy and geomechanics of the surrounding rocks with depletion. In the well engineering side, the deviation into the salt zone must be analyzed. Wellbore materials must be resistant to collapse and proper to high CO_2 content. Some projects could involve Extended Reach Wells.

Figure 2. (a) GIOp loop of actions; and (b) Philosophical approach of GIOp



Risers and thermal insulated flow lines must be qualified for more than 2,000 m water depth, considering CO_2 content and high pressures. The lines must be resistant enough to support high pressure gas injection. Flow Assurance and Artificial Lift teams have to prevent hydrate formation, wax deposition in long pipelines, scaling control and provide the temperature management along the lines. Gas pipeline must be projected to be larger than 18" in water depths of more than 2,000 m.

The production units will be anchored in deep waters. It is important to preserve the local content in future projects. The implementation initially will count on standardized FPSOs topsides (replicated projects), but new technologies will be considered, like TLP, SPAR, Semisub and FPDSO.

It will be very important to implement new technologies in logistics, considering the long distance to the coast (300 km) and the impacts on people transport (air and sea), fluids and cargo transportation. In that sense, it will be critical to guarantee the logistic support to the Santos Basin in an integrated system with flexibility, installing new infrastructure (ports and airports), looking for new models of offshore logistics in order to have significant gains.

It was clear at the time, the need to change the way of working. The model used was based on individual work, combined in multidisciplinary decisions taken in meetings. The complexity was to have the right people attending at the proper time in the correct place. To bring the demanded information and the engineering tools to the meeting rooms was also fundamental. This system was good enough to put Brazil in the selected list of the self sufficiency in oil producers, few years ago.

Petrobras has grown very fast through the last years. So, which direction to go? What is the recommended model?

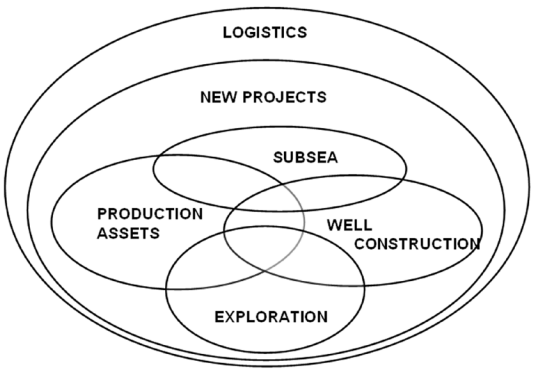
In order to answer these questions, Petrobras high management decided to follow the oil industry tendency: Business Intelligence. One group of executive and general managers was created in the company headquarters to decide about the expectations, objectives and drivers. At this moment, the initiative called GIOp was created.

The implementation of GIOp will result in an increase of operational security in the Santos Basin activities, as per it allows a best control and better supervision of facilities and processes, from onshore environments, minimizing transportation of people, equipment and materials in large distances.

The basic concept of this new philosophy is the integration of the operations, focusing on people, processes, technology and governance, aiming to increase operational safety, efficiency and reduce costs. Regarding people, it is expected to enhance the collaborative way of working that eliminates barriers and interfaces across the employees. Whenever it is possible, GIOp will redesign and simplify processes, integrate disciplines, plan onshore and take like a priority the predictive maintenance. The main focus will be on solutions increasingly intelligent and innovative, with preference to existing technologies. It will also be very welcome the adoption of technologies developed by partners in the oil industry and universities.

The scope was considerably wide. It was decided to drill it down to the corporate areas, to potentialize GIOp implementation across the organization. A general picture of the application of the initiative to Petrobras organization is given in Figure 3.

Figure 3. GIOp implementation map



Russo et al. (2010) states that: "the objectives should be clearly aligned with the company strategy; otherwise, successful change management becomes an even greater challenge." The GIOp approach involves a systemic view, considering infrastructure elements and addressing solutions to operational problems in order to get the following objectives:

- Increase production efficiency,
- Lower operating costs,
- Enhance reservoir recovery factor,
- Reduce investment costs.

The drivers were divided in areas, like processes, management, technology, people and infra-structure.

PRE-SALT IN SANTOS BASIN: A CASE OF APPLICATION

Santos Basin GIOp Implementation Strategy

To enhance the implementation of GIOp in Pre-Salt, the strategy of creating a pilot project was adopted. Thus, it was possible to analyze work processes and technologies at an early stage, guide the implementation of GIOp and gain initial experience in implementing the concept of Integrated Operations in a complex scenario like Santos Basin.

The GIOp implementation project follows the traditional FEL (Front End Loading) phases: Evaluation, Conceptual Design, Basic Project, Implementation and Execution. One of the most important benefits of this pilot strategy can be understood in Figure 4, where the Basic Project design phase occurs simultaneously with the pilot. This overlap has an important reason, because the work processes mapping will take place in the basic design, considering the concepts of the new work philosophy to be adopted. At this point, it becomes extremely necessary to analyze the lessons learnt from the pilot.

At the end of the basic design phase, the pilot experiences must be finished. After this step, all solutions already implemented will be considered like definitive, except for the collaborative environment setups. In order to enhance the layouts of the final building (forecasted to be ready in 2014), the strategy is to provide the first definitive solutions in temporary environments. For the final setup definition, it will be taken into account all the lessons learned from implementing these solutions in temporary environments.

The strategy of the GIOp implementation using temporary environments allows some extra benefits, like:

- Anticipation of value;
- Higher level of conscience in setup designs;
- Change Management: involving users in the redesign of processes and the final layout;
- Reduction of risk with the anticipation of solutions in stages.

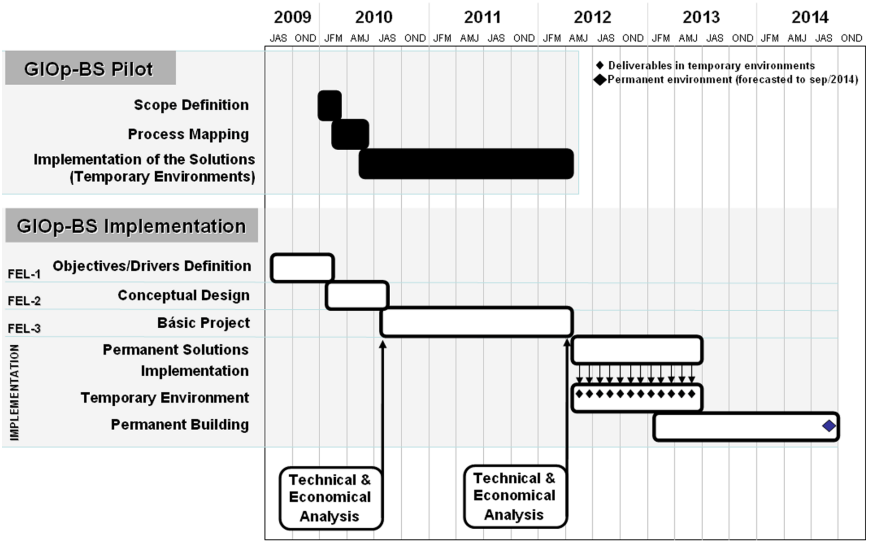
The pilot implementation was divided into four steps:

- Scope definition (selection processes to be addressed first),
- Process mapping,
- Collaborative environments allocation,
- Development and deployment of solutions.

The concept of the pilot was based on the application of already proven technologies and preferably existing initiatives in Petrobras. Moreover, the basic premise was the use of existing facilities for deployment of the collaborative environments. These facilities allow adjustments to follow the changes coming from the defined work processes.

The scope of the solution to be operationalized in the pilot of GIOp-BS was based in other Petrobras previous initiatives as it was mentioned

Figure 4. GIOp-BS: Strategy of implementation



previously in this Chapter. Processes with good level of redesign and high scalability potential were selected.

The original focus was the application of Integrated Operations on Tupi Field (today, called Lula Field). However, later it was found important to include (see Figure 5):

• Mexilhao Platform: to develop a better approach of the logistics comparing this fixed platform and the Lula (Tupi) FPSO.

• UTGCA (onshore gas facility): to investigate the differences of applications in different production plants, comparing with the Lula (Tupi) FPSO.

Then, it was decided to include all the current production units of the Santos Basin to set the final scope of the GIOp-BS Pilot, with the following objectives:

- Develop skills in process redesign;
- Enhance knowledge in design setups, to reflect the process redesign;
- Improve the methodology of process mapping, so that modeling can provide the layout and human resources requirements as well as the proper engineering tools and systems demands.

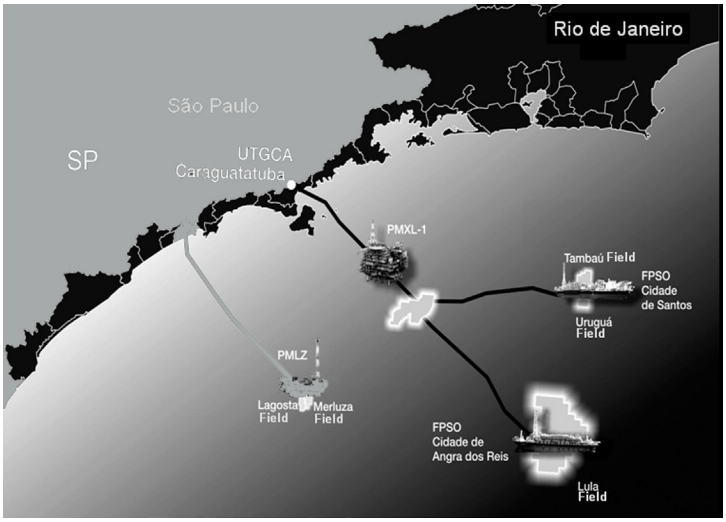
Pilot Process Mapping of Operational Capabilities

Considering previous initiatives in Petrobras, the modeling portfolio focused on processes such as: production plant surveillance, well surveillance, turbo machinery surveillance, production loss management, production test validation, maintenance planning, gas lifting optimization, material balance with interference, reservoir surveillance, among others. Some of the most important steps in this analysis were the human aspects, more specifically, mapping skills and competences. This mapping was done in cooperation with HR Department in Petrobras.

Competence Mapping

The main purpose of the competence mapping phase was to find the right employees related to the processes on the pilot scope. During the mapping sections, the change management team identified the skills and human capabilities demanded. Next step was based on the definition of the GIOp-BS Pilot residents and affected personnel.

Figure 5. Santos Basin production concept



After the competence mapping, a survey in the task force was used to find the candidates to be GIOp residents (surveillance experts and support team) and also to understand the affected personnel. An intensive change management program was then carried out.

Integration Solutions Implementations: A Technology Step Forward

The scope of GIOp pilot in Santos Basin is being developed in house by Petrobras. Some available or existing solutions have been selected for implementation and development, like: surveillance using PI (Plant Information) covers operating units and wells of the Pre-Salt. There is also an IT Portal with other solutions that were scaled to the pilot, like: virtual metering, production test validation, reservoir surveillance, material balance with interference. Other initiatives that are being integrated into the Pilot are integrated planning and logistics (IPL), drilling centers, operational daily meetings with production centers, operational integrity and contingency, among others.

Collaborative Environments Construction

GIOp-BS Project shall include new facilities being built by Petrobras 2014. In order to anticipate important issues, develop the ability to redesign collaborative environments and provide first experiences on Integrated Operations in the Santos Basin, a temporary building was dedicated for the pilot project.

The pilot setup was designed according to the concept of loops (fast, medium and long). The fast loop environments promote the application of surveillance, in order to monitor of processes in real time, while the medium and long loops contribute to longer-term decisions that can be taken in a multidisciplinary way (see Figure 2). According to Dutra et al. (2010): "The use of real-time production-operation systems enables strategies for asset managers to make faster decisions and provide better solutions to asset operational issues." The physical design took into account the diversity of people who will use it, in the different processes, the ergonomics and the collaboration involved across the people who

attends to the pilot center. Other areas (medium and long loops) can physically interact and thus provide the collaborative environment in a full concept.

All the pilot environments were built according to the drivers of flexibility and low cost, using simple and versatile visualization systems. So, all the necessary changes in the learning curve can be potentialized.

Currently, to cover the 15 cases operationalized, GIOp Pilot has approximately 300 m2 of environments on operation. This area should be tripled in 2012 to allow a better set up and also to include the Santos Basin Drilling Centers.

Santos Basin Opportunities Portfolio: Overview

For the first phase of the GIOp implementation on Santos Basin, the best practices were identified with visits to other operators and service providers, using the consulting services of CERA (Cambridge Energy Research Associates). International visits to institutions in the Gulf of Mexico and North Sea were performed and two intensive workshops were carried, with operators, service providers and logistic companies. At this point, Petrobras E&P was mature enough to set the GIOp drivers into five groups: processes, management, technology, people and infrastructure.

The methodology for defining the conceptual scope of the Implementation of GIOp in the Santos Basin is based on the opportunities for application ("pain points") of the concept of Integrated Operations to the future scenario of the Santos Basin (2020/2030).

The first step was to express in a clear, objective and didactic way the concept of Integrated Operations. Secondly, drivers and objectives (which were outlined in an earlier stage of development) were explained in a language that everyone can understand.

Subsequently, the scenario study of the Santos Basin was conducted. This was extremely complex, since it should be designed in the future. In preparing the study, a multidisciplinary group of experts was set up to prepare this study. The theme was divided into segments in a sequence connected to the natural production of an oil accumulation: exploration, reservoirs, well construction and production (complex element consisting of collection, operation, maintenance and distribution). Logistics is a key element and it was considered separately, as it relates to all other scenario components.

A multimedia was used to represent the scenario. This multimedia didn't have only the goals for the dissemination of GIOp concepts to the workforce. Its main role was to rise provocative elements to the dynamics applied in the opportunities assessments.

The dynamics of opportunities assessment was defined in two directions: top down and bottom up. The top down approach goal was to set drivers and concerns (issues or strategic concerns). It was applied to the Petrobras high management (Executive Managers, General Managers and Unit Management Committee). In a further analysis, these findings (attention points) were put together with the Integrated Operations concept to really understand the ones that can effectively be solved by the GIOp (this is the main result of the dynamic top-down). The bottom-up dynamics was applied to professionals with great expertise, carefully selected in their respective specialties. The opportunities assessment was composed by 33 interviews top-down and 140 bottom up.

Once prospected the opportunities, as seen earlier, these were consolidated. Some findings were not opportunities, as per they didn't have a relation with the Integrated Operations concept. However, some of these findings were important because they affect in many process optimization possibilities.

The next step was to establish the correlation between the opportunities (bottom-up) and the attention points (top-down), as demonstrated latter in this chapter. Finally, the Conceptual Design was validated through workshops involving Petrobras professionals from many disciplines.

Petrobras High Management Perspective

The attention points that were diagnosed in the top down approach were classified as:

- Structure elements: consist of aspects that are related to Santos Basin, which can significantly impact GIOp (e.g., the physical location of the collaborative center directly impacts GIOp as it is an important element of infrastructure) and
- Expectations (or concerns) to be solved by GIOp, that were then linked to opportunities consolidated previously, as described in the following items.

Figure 6 (a) and (b) demonstrates how opportunities and expectations were matched.

Balance, Prioritization of the Opportunities, and Economics

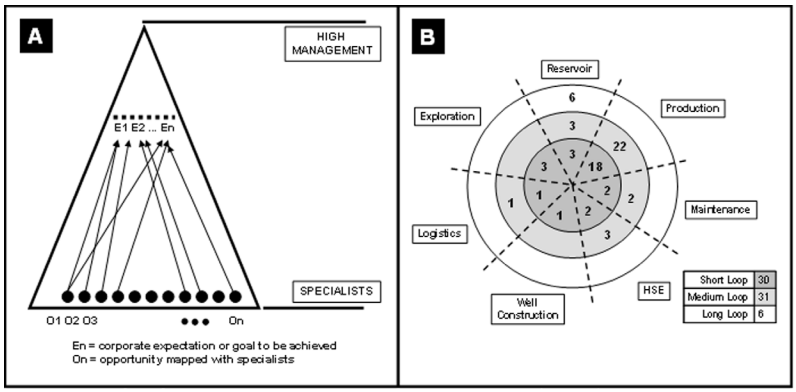
After the opportunities portfolio definition, it must be balanced and prioritized to guarantee that all the disciplines, loops and parts of the organization were properly covered. The idea was to promote a conceptual overview of the implementation project scope, in order to diagnose any trends and gaps. Figure 6B represents the philosophical view of GIOp in Santos Basin with the detailed information provided in the Conceptual Design and it can be observed:

A. There is a balance between the medium (30) and fast loops (31);
B. The long loop is very important for reservoir (6) related opportunities;
C. There are specific opportunities for HSE;
D. The highest number of opportunities occurs in production, which is entirely consistent with the scope of an Operational Unit;
E. There are few opportunities related to well and logistics, since a good part of the scope of these areas is divided with other GIOp´s (GIOp-LOG and GIOp-Wells) as discussed previously in this chapter (see Figure 3).

The following criteria were used for prioritization of opportunities:

A. Number of attention points or expectations of top management that the opportunity is related. Thus, as much expectations of the corporation an opportunity covers, the more important it is.
B. Time requested to implement the opportunity. If an opportunity (gas lift optimization, for

Figure 6. (a) GIOp-BS: opportunities and expectations match and (b) GIOp opportunities distribution across loops and disciplines



example) will only be used in a few years, it may (despite its importance at the time of use) be prioritized in the lower level.

C. Number of opportunities associated, which reflects the importance of opportunity in the context of the conceptual scope.

D. Number of times that the opportunity came in the bottom-up assessments. So, if an opportunity was repeatedly reminded, this should be a reflection of importance.

All criteria were leveled with a score of zero to ten.

A Technical and Economical Study was demanded in order to approve the Conceptual Design. The benefits of GIOp-BS were estimated with the reference to projects of other oil operators, available from the CERA Consulting.

A Journey to the Future Santos Basin: Process Mapping of New Operational Capabilities

One of the key elements of GIOp is the correct mapping of redesigned processes of the Santos Basin, with special attention to integrated planning and logistics, because of challenges imposed by the Pre-Salt development.

It is supposed to map the processes that are connected to the opportunities described in conceptual design. So, it is important to identify the existing and new ones (considering that Pre-Salt is a Greenfield). During the process mapping, basic KPIs will be defined. These indicators will measure the efficiency of the processes, enabling the continuous evolution. The mapping will play an important input for the definition of technologies of integration, solutions and change management. Moreover, as a result of this process, requirements for building the collaborative environments will also be derived from this phase of the project (see Figure 4).

The definition of the processes allows the specification of tools to assist in implementing the organization's processes. In addition to the solutions to support the processes mapped, engineering tools will be analyzed, as well as remote control systems operations in Santos Basin. These tools will be considered on a case by case basis and may use technologies already existing in Petrobras, from vendors on the market or the development of specific solutions.

The Sensitive Element: People

GIOp will provide a strong change in the operation processes and decision making in Santos Basin. This is a key success factor, concerning:

- Definition of the professionals profile of who is involved in the collaborative processes;
- Plan to support the cultural change imposed by these new processes;
- Appropriate training plan to the new structure;
- Analysis of working schedules and shifts imposed by the processes (24/7).

Some Important Requirements

1. The telecommunications infrastructure has a fundamental role in this future context. The main goal is to establish a reliable telecommunications infrastructure, with high availability and robustness, capable of supporting products and services, both onshore and offshore in Santos Basin and enable to make the integration with other Petrobras Units. There is an installation campaign implementation of 2.000 km of fiber optics to cover the telecommunications needs in all production units of Pre-Salt.
2. There are initiatives for the logistics distributed across Petrobras at various levels of application, such as: logistics of people, boats, rigs, among others. The interfaces will

be identified with these disciplines, enabling the requirements to the related to projects.

3. The platform topside systems must provide information about their real-time operations to the GIOp processes. To make this a reality, certain projects or infrastructure already installed must suffer modifications. In the same way, Integrated Operations must be considered in the future projects of the Pre-Salt units.
4. Considering the requirements of GIOp, existing initiatives will be evaluated at Petrobras in terms of sub-surface facilities. These adjustments and evaluations may generate new requirements and assumptions for existing projects or new ones.
5. After the redesign, the new work processes mapping of Santos Basin could lead to changes in decision making. These changes will be submitted through the requirements to make the necessary adjustments in the organization. A review of the corporation structure possibly will be necessary.
6. In the implementation of GIOp, interfaces of collaboration in various processes must be clearly understood in order to locate the task force in the best locations, considering the new buildings to be ready in 2014.
7. GIOp will provide solutions for monitoring and optimizing the management of oil and gas distribution, such as offloading. The processes identified as essential to this task will be properly mapped and may have solutions with their respective collaborative environments.
8. With the focus on collaboration across disciplines, using redesigned work processes and data from real-time operation, the collaborative environments will have an essential role in the integration process. The Center for GIOp will enable faster and safer decision making, considering the integration of offshore and onshore teams. The process mapping will be the base to define the collaborative environments for the initial implementation of GIOp in the Santos Basin.

Final Setup of Collaboration

The GIOp center will have a strong focus on the control of situations that may become critical and result in production losses and identify optimization opportunities. After the process mapping, many requirements will be available to be developed and implemented. In addition, the needs of collaborative environments will be clear. As seen earlier, to enhance a correct definition of collaborative environments, the construction of these lay outs will be defined in two steps. The first stage will be based on temporary environments, with solutions in place. The lessons learnt from the first step will be used to define the final setup, in a second step to be ready in 2014.

THE BEST WAY TO GO SAFELY: GOOD GOVERNANCE AND COMMUNICATION

Governance Model

The implementation of GIOp in the Petrobras E&P segment is supported by a governance model that was created to ensure participation from all areas. Management engagement was considered a success factor in every level of the formal structure. The main concerns are related to the sponsorship in all the layers (that must be preserved and potentialized) and the dissemination of the lessons learned (see Figure 7). “The key to success was certainly driven by strong management sponsorship and willingness of the asset teams to adapt to the new approach.” (Lima et al., 2010).

The governance model has centered on the involvement and sponsorship of all management levels, in order to the implementation to succeed and to the proper continuous improvement of the

Figure 7. GIOp implementation in E&P Petrobras: Governance model



redesigned processes. The governance methodology was framed to provide the participation of all involved in both technical and management issues. The discussions and deliberations are supported by a strong base, which is responsible for the follow up of the implementation of GIOp.

The Figure 7 describes a global picture of the governance model. From the top to the bottom of the triangle there are the following levels:

Level 1: Steering Committee

The Steering Committee is ahead of the check of the alignment with the strategic programs inside Petrobras, decide about guidelines, monitor the Change Management and also make the correct critical analysis of any proposed corrective actions and approve them. The members are senior managers from all areas involved.

This committee meets quarterly, or in extraordinary situations.

Level 2: Executive Committee

Change Management is the main role of the Executive Committee. So, the active participation of its members in action plans is fundamental (communication and implementation), considering specific critical analysis and proposing corrective actions when necessary and submitting decisions that demand approval to the Steering Committee.

The Executive Committee is formed by general managers of various units involved. They meet every two months.

Level 3.:Operational Committee

The responsibilities of the Operational Committee are connected to the execution of the action plans, identifying and sharing best practices and common problems and proposing actions to the Executive Committee and to the Operation Units. This committee has an important role in integrated planning issues, production loss management, operational efficiency improvement, integrity in topside facilities and well construction. This committee acts in a common approach to integrated solutions addressed to specific issues that require special attention.

The members of the Operational Committee are the local coordinators and professionals in charge of GIOp implementation.

Communication Plan

The basic element is to align the communication strategies together with the governance model. Thus the communication plan adopted by Petrobras for the GIOp implementation was established after the investigation and understanding of the best practices of other operators and suppliers.

The main aspect is that the communication must be from the highest top of the organization to the base. The manager of each area or group should be responsible for delivering the messages. Based on this principle, it was established a Communication Plan related to all levels of management. After receiving and assimilating the concepts one level of the organization should be in charge of passing the message down until reaching the operational basement.

Figure 8 shows the management levels from N1 to N3 and also to the WF (Work Force) in

a clock view. The arrows indicate which level should be involved at an appropriate time. It also indicates two events to verify the effectiveness of communication at some level.

At midnight (Figure 8), it was made the communication of operational principles from N1 to the Work Force. At 3 o'clock, it was performed an intensive road show, regarding GIOp objectives, principles and drivers. The high management of all operational units was involved.

The managers of each operational unit were in charge to deliver the message to the lower management level, at 06 o'clock. The 9 o'clock represents that the communication was done from the last level management to Work Force.

CONCLUSION

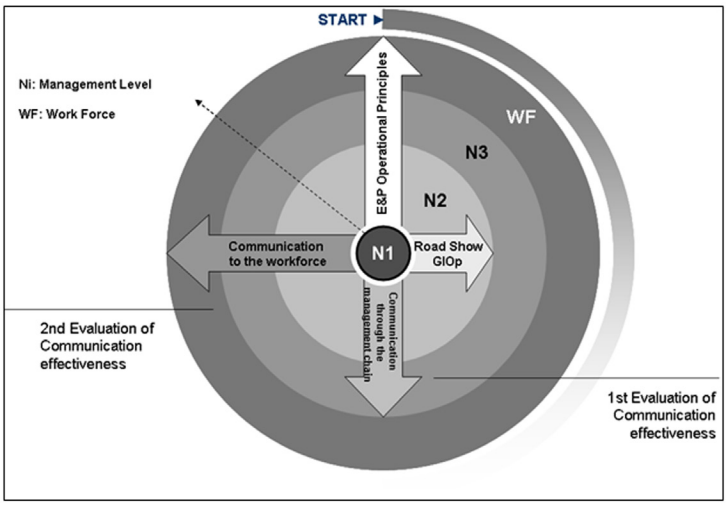
Petrobras, even with all experience accumulated over the time, needs to operate in a different and innovative way. This is motivated by new exciting challenges that have arisen. Thus, the Integrated Operations Management appears to be the most appropriate option. For the successful implementation of this philosophy, the first step was to consider the industry and academy knowledge. Some important elements have been shown to be fundamental, like the right implementation methodology, the establishment of efficient governance, the sponsorship, the proper change management and a clear definition of the objectives, strategy and drivers. The pilot approach is proven to be positive. In this direction, Petrobras is implementing GIOp in its E&P units.

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Figure 8. Communication clock



CGIOp), Luiz Felipe Bezerra Rego (E&P-ENGP/EP), Tuerte Amaral Rolim (E&P-PDP), Armando Goncalves de Almeida (E&P-PDP/CTPDP), Erardo Gomes Barbosa Filho (E&P-SERV), Ricardo Albuquerque Araujo (E&P-SERV/US-LOG), Mauricio Antonio Costa Diniz (E&P-SERV/US-SUB), Evely Forjaz Loureiro (E&P-CORP/RH), Claudia Marcia Cabral de Carvalho del Souza (E&P-CORP/CSI), Jose Luiz Roque (E&P-CPM), Mario Caminatti (E&P-EXP), Carlos Henriques Ribeiro da Cunha (TIC/TIC-E&P).

REFERENCES

Campos, S. R. V., et al. (2006). *Right time decision of artificial lift management for fast loop control.* Paper presented at the Intelligent Energy Conference, SPE 99956-MS.

Derenzi, D., et al. (2009). *A successful approach in integrating people, process, and technology inside collaborative environments: A practical view of challenges and lessons learned*. Paper presented at the Intelligent Energy Conference, SPE 123287-MS.

Dutra, T., et al. (2010). *Monitoring and optimizing oil fields by a real-time production operation (RTPO) system*. Presented at the Intelligent Energy Conference, SPE 138316-MS.

Formigli-Filho, J. M., et al. (2009). *Santos Basin's pre-salt reservoirs development: The way ahead*. Paper presented at the Offshore Technology Conference, OTC 19953-MS.

Lima, C. B. C., et al. (2008). *GeDIg Carapeba - A journey from integrated intelligent field operation to asset value chain optimization*. Paper presented at the Intelligent Energy Conference, SPE 112191-MS.

Lima, C. B. C., et al. (2010). *State-of-art digital oilfield implementation in Petrobras Campos Basin*. Paper presented at the Intelligent Energy Conference, SPE 128766-MS.

Moises, G. V., et al. (2008). *GeDIg: Petrobras corporate program for digital integrated field management*. Paper presented at the Intelligent Energy Conference, SPE 112153-MS.

Russo, E. E. R., et al. (2010). *Benefits quantification and change management in Petrobras corporate program for digital integrated field management (GeDIg)*. Paper presented at the Intelligent Energy Conference, SPE 128675-MS.

ADDITIONAL READING

Adeyemi, O. S., *et al.* (2008). *Implementing "I Field" initiatives in a deepwater green field, offshore Nigeria*. SPE 115367-MS.

Alkhadhuri, S., et al. (2006), *Integration of People, Process and Technology for Right-Time Production Management and Optimization in Brunei Shell Petroleum*, presented at the Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 99243.

Bieker, H. P., et al. (2006). *Real-time production optimization of offshore oil and gas production systems: A technology survey*. Presented at SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 99446.

Edwards, T., et al. (2006). *Advanced collaborative environments in BP*. Presented at SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 100113.

Ershaghi, I., & Omoregie, Z. (2005). *Continuing education needs for the digital oil fields of the future*. Presented at the SPE Annual Technical Conference and Exhibition, held in Dallas, USA, SPE 97288.

Formigli, J. M., et al. (2008). *Santos Basin pre-salt cluster: How to make production development technical and economically feasible*. Presented at Rio Oil and Gas Conference, Rio de Janeiro.

Garcia, A. D., et al. (2010). *Methodology for oil production loss control in a digital oilfield implementation*. Paper presented at the Intelligent Energy Conference, SPE 127517-MS.

Garcia, A. G., *et al.* (2010). *An implementation of on-line well virtual metering of oil production*. SPE 127520-MS.

Hauser, M., & Gilman, H. (2008). *Evolution of decision environments: Lessons learned from global implementation and future direction of decision environments*. Presented at SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 112215.

Hawryszkiewycz, I. T. (2007). *Technical strategies for supporting the evolution of collaboration*. Presented at the International Conference on CSCW in Design (CSCWD) held in Melbourne, Australia, 2007.

Jacobs, J. (2005). *White paper: Digital oil field of the future – Lessons from other industries*. Cambridge Energy Research Associates, Inc (CERA), Summer 2005 Research White Paper.

Kanvinde, S., et al. (2008). *Integrated competence: Operator-service company integration increases the performance and value of the well construction process*. Presented at the SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 112018.

Kepner, C. H., & Tregoe, B. B. (1978). *The rational manager – A systematic approach to problem solving and decision making*. Princeton, NJ: Kepner-Tregoe, Inc.

Lacerda, G. M., et al. (2008). *Alto do Rodrigues GeDIg pilot - Case study for continuous steam injection recovery combined with real time operation*. Paper presented at the Intelligent Energy Conference, SPE 112242-MS.

Lima, C. B. C., et al. (2010). *Closing the loop - Integrating predictive surveillance with remote control operations*. Paper presented at the Intelligent Energy Conference, SPE 128761-MS.

Magdaleno, A., et al. (2007). *Practical experience in designing business processes to improve collaboration*. Presented at 3rd International Workshop on Business Process Design (BPD'07) in conjunction with the 5th International Conference on Business Process Management held in Brisbane, Australia, 2007.

Manoel, F. S. Jr., *et al.* (2005). *Technologies trials of intelligent field implementation in Carmopolis field*. Presented at ATCE, Dallas, Texas, USA, SPE 95917.

Millete, P. (2006). *New work processes and operations form: Efficient data utilisation and online*. Presented at the SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 100275.

Moitra, S. K., et al. (2007). *A field-wide integrated production model and asset management system for the Mumbai high field*. Presented at the Offshore Technology Conference, held in Houston, Texas, USA, OTC 18678-PP.

Murray, R., et al. (2006). *Making our mature fields smarter – An industry wide position from the 2005 Forum*. Presented at SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 100024.

Nordtvedt, J. E., & Unneland, T. (2006). *Implementing real-time asset management: A practical perspective*. Presented at the SPE Intelligent Energy Conference and Exhibition, held in Amsterdam, The Netherlands, SPE 99468.

Palen, W., & Goodwin, A. (1986). Increasing production in a mature basin: The choke model. Presented at the SPE European Petroleum Conference, Milan, Italy, SPE 36848.

Rebeschini, J., et al. (2010). *Integrated optimization system for short-term production-operations analysis*. Presented at the Intelligent Energy Conference, SPE 138436-MS.

Sagli, J. R., et al. (2007). *Improved production process optimization through people, technology and process*. Presented at SPE Annual Technical Conference and Exhibition held in Anaheim, CA, USA, SPE 110655.

Stundner, M., & Oberwinkler, C. (2004). *Self-organizing maps for lithofacies identification and permeability prediction*. Presented at the SPE Annual Technical Conference and Exhibition, held in Houston, Texas, USA, SPE 90720.

Unneland, T., & Hauser, M. (2005). *Real-time asset management: From vision to engagement – An operator's experience*. Presented at SPE Intelligent Energy Conference and Exhibition, held in Dallas, Texas, USA, SPE 96390.

Vinturini, W. L., et al. (2008). *The Fazenda Alegre journey into intelligent energy - Lessons learned from a successful holistic approach of people, process and technology aligned to business strategy and results*. Paper presented at the Intelligent Energy Conference, SPE 112160-MS.

KEY TERMS AND DEFINITIONS

CIM-TBM: The integrated center for monitoring turbo machinery (located in Campos Basin), that applies diagnostic algorithms to evaluate the conditions of performance of turbo machinery.

FEL (Front End Load): The concept to implement projects in Petrobras, which goes through four phases: opportunity assessment, conceptual design, basic design and subsequent deployment to start of production.

GeDIg: (acronym to Digital Integrated Management, in Portuguese): The application of Integrated Operations to the assets (smart fields). Petrobras carried 6 pilots of GeDIg to prepare the ground to the GIOp implementation.

GIOp (Acronym for Integrated Operations Management, in Portuguese): Defined as the integration of disciplines, service companies and the organization, combined with data in the relevant time, considering the redesign of the important work processes, in order to have better decisions and more efficiency, using collaborative environments. The main focus is to be proactive instead of reactive, forecasting situations before they become critical and identifying opportunities to gain and improve these processes.

OCC (Operational Control Center): A center dedicated to the production management across the Campos Basin and also collaborates in the treatment of crises, emergencies and contingencies that affect the Units. It was an important element (together with GeDIg) in the Petrobras the learn curve in Integrated Operations.

SCR (Remote Control Rooms): A center to remote control offshore platforms and also to enable interaction with other collaborative environments and facilitate the decision-making.

Seed Field: The early period of life of a new concession before the declaration of commerciality. The production will begin in subsequent cycles of Green Field and later Brown Field, until the time of the final abandonment.

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Chapter 15
The Introduction of a Hand-Held Platform in an Engineering and Fabrication Company

Irene Lorentzen Hepsø
Trondheim Business School, Norway

Anders Rindal
Trondheim Business School, Norway

Kristian Waldal
Trondheim Business School, Norway

ABSTRACT

Fabricom is currently looking for ways to improve their collaborative capabilities. They have assessed hand-held devices as means to increase efficiency and availability throughout the organization. This chapter focuses on the organization Fabricom, and seeks to uncover which capabilities lie within the hand-held devices, and what kind of effects the implementation of such devices could have on Fabricom's work processes. Through an abductive approach, based on observations, semi-structured interviews and document analysis, the authors focus their attention on the work-flow and communication practices in Fabricom. These findings are viewed in light of structuration and practice theory, supported by aspects from actor-network theory. Findings lead to the notion that the implementation of a hand-held platform in Fabricom can contribute positively to the interaction within the organization. The digital work process is capable of providing access to real-time data and real-time communication throughout the organization. This may contribute to a closer interaction between the divisions, and provide a better basis for problem solving and task performance.

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INTRODUCTION

Most offshore engineering demands coordination and collaboration between several actors with diverging focus and competence across organizations. In addition to geographical distance, high quality demands, challenging environments and high risk, collaboration between involved actors are a key challenge in order to execute a coordinated and smooth practice that result in adequate solutions. Fabricom AS, a part of GDF Suez Energy, is delivering engineering services to the oil and gas industry; offshore and onshore, front-end and field development, maintenance and modification projects, as well as construction services. Fabricom is looking at the possibility of using hand-held devices to improve the work processes from planning and design, through production to construction and operation. In this chapter we discuss challenges and opportunities of hand held devices using Fabricom as a case. Our initial discussions with Fabricom led to this project. We have studied their work and discussed the idea of developing scenarios for using hand-held devices within all three departments; engineering, manufacturing and installation. This subject was of great interest to us as researchers, an idea that triggered the engineering management and a likeable idea for most employees in the company.

Integrated Operations (IO); information and communication technology enabling new ways of working, new practices and new forms of collaborations, is one of the main focuses in the oil and gas industry. Fabricom as vendor to drilling and production companies was drawn to IO both to fulfill the demands of the production companies and to improve their work processes to increase quality and reduce costs. Their focus is now on hand-held devices since this technology facilitates collaboration between internal departments, collaboration with external partners, improved feedback loops, documentation, information gathering and increased availability of crucial information. The potential of this technology inspires. After presenting existing work practices we discuss the expectations Fabricom have to hand-held devices. Building on Edwards et al's (2010) generic insights and lessons learned from experiences of comparable processes in this industry we discuss the implications of shared understanding, real time data, effective leadership, trust, self-synchronization, collaborative environments and technological pitfalls. From our interview data, from the process view on implementations, and from our theoretical interest, we approach all three research streams presented by Orlikowski (2008). We present the actors and objects as discrete entities (research stream I) in the way most of our informants did, as mutually dependent ensembles (research stream II) the way process oriented perspectives does, and further we discuss the challenges of future practice by understanding the objects or actors as socio-material assemblages (research stream III). Our theoretical perspective is then to understand the opportunities and challenges of hand-held devices as both social and technical by approaching the interconnection between human and non-human actors.

Fabricom was established in Norway in 1992. Organic growth and acquisitions have made them a significant provider of engineering work in the Norwegian oil and gas industry. Today they present their work in this way: "With extensive, multidisciplinary competences, use of the best available technology, innovative solutions and effective work processes, Fabricom aims to meet the customer's needs and requirements". They are situated at several locations in Norway, with main office, construction and warehouse in Stavanger, the engineering office in Trondheim, and operations at Orkanger. We have studied the engineering department where we have observed the interaction regularly over a period for 3 months. Our stay and our connection with the engineers have made our methodology close to ethnography (Postholm, 2005), as we got engaged in their daily life and work experiences and got familiar with the engineers and their way of thinking during

this period. The informal connection, and the way we learned to know the engineers, their work and their way of understanding both challenges and opportunities have influenced our study, since we got closer to them than the other departments. Being there with them eased our access to relevant documents and helped us interpret and understand their work through models, flow-charts and descriptions. In-depths interviews have been run with project managers and engineers from the engineering department, fabrication manager and installer from the manufacturing department, and offshore installer from the installation department. Some of the informants have experiences from more departments and more parts of the complete workflow. Through the intensive study of both the existing practice and of their considerations of the hand-held device, we have fruitful information to discuss the opportunities and challenges related to this technology. Still, the data we have got from the manufacturing and the installation departments may be limited to be specific to the attitude and expectations of the persons we interviewed.

THEORETICAL BACKGROUND

We are inspired by the work of Wanda Orlikowski, both her work based on Giddens (1984),the structuration theory (Orlikowski, 1992) and her work on socio-materiality (2008; 2009. Further, when discussing challenges and opportunities of hand-held devices in the case of Fabricom, the notion of "capabilities" became relevant. Studying innovation processes where new technology enables new ways of collaboration, capabilities have been used increasingly more frequent (Weeks, 2009; Iyer and Henderson, 2010; Raymond et al, 2010; Zonooz et al, 2011). Capability thinking points at the opportunities, the abilities and the capacities, as a capability approach addresses both technological and social options as Henderson, Hepsø and Mydland describes in this book. This is the situation with Fabricom. They have been aware of several interesting capabilities that could be enabled by hand-held devices. Realizing the capabilities there are several pre-conditions, both technical and social. To address the challenges of realizing the intentional capabilities we build on the work of Edwards et al (2010). Presenting the insights and learning's from the application of Intelligent Energy in several major oil and gas companies, they suggest an alternative way of describing an Intelligent Energy project. Edwards et.al (2010) argue that a multi-dimensional integration project integrates the dimensions of:

- Technologies- Data and information from multiple sources
- People, Process, Technology, Organization & Physical Environment
- Multiple geographical locations
- Many disciplines and functions
- Between the company and its suppliers
- Along the value chain, reservoir to customer
- Time, integrating the working time steps of different process, minutes, hours, days, months, years.

We build our discussion in this paper on the insights Edwards et al (2010) present regarding the approach of Multi-dimensional integration. This paper examines the collaboration between three internal departments within an organizational context. These departments belong to different organizations as customers, other suppliers and competitors. Since shared situational awareness is a key to realize the capabilities, we discuss the development of shared mental models in accordance with the iterative approach of Paul Carlile (2004). Carlile extends Shannon and Weaver's (1949); communication theory. He defines the three levels of communication complexity: a syntactic, a semantic and a pragmatic approach to understand sharing and assessing knowledge across boundaries. The iterative approach indicates the dynamics of communication across boundaries, where shared syntax may be developed through interaction.

Looking at the hand-held device as a boundary object (Bowker & Star, 1999; Carlile 2002) has been fruitful to understand existing and potential communication possibilities and challenges. Bechky (2003) have done research based on theories of Carlile and Orlikowski. She shows how physical objects can work as beneficial boundary objects, as a mean to make a shared meaning between communities of practice. Her empirical findings are done in an organization quite similar to Fabricom. Considering our empirical findings in relation her perspective has helped us describe the internal relations of the organization.

HAND-HELD DEVICES IN FABRICOM

Existing Work Practices

The tasks on a project are performed by three geographically distributed departments in Fabricom. These departments focus on their respective parts of the value chain, and have dissimilar work contexts while still being interdependent. The information between these departments is being transferred in a work package which consists of detailed documentation on how the contents of a contract is to be manufactured and installed, examples of documentation being; bill of materials, schematics and 3D-plots. The content of the work package is collected from Fabricom's internal systems as well as the clients systems. The work package is developed by the engineers and is subsequently sent to the manufacturing and installation department where the tasks are performed according to the work package. The difference in work context is seen between the engineers who have an abstract relation to the physical work context, and the manufacturing and installation personnel who work hands on with manufacturing and installation.

The engineering department performs their work mainly using computers and digital systems. They transfer their digital version of the work package to the manufacturing and/or installation department where the work package is printed. The manufacturing and installation department then perform their work based on these hard copies. After the work is completed, the paper-based work package is returned with potential markups back to the engineers. This result in a delay of up to two weeks before paper-based information from installation personnel gets reported back to the engineering department for digitalization and system update.

The institutional border between the departments and the difference in work context leads us to believe that interests, meaning and behavior differs between them. According to Wenger (1998) each department can therefore be defined as a community of practice. In spite of this, the departments are interdependent through sequential work-processes. As an example the installation department relies on manufactured products to do their work offshore, and the workers offshore rely on the engineers to supply them with correct information in the work package. Situations where the work package diverges from what is physically possible to perform can arise, and must be resolved so that commissioning can be completed. The way departments perform their tasks and how they interact is crucial in a successful commissioning. Trust in each other's abilities is important in this setting. The work package is the primary route for transferring information between the departments, and can be seen as a boundary object. The information flow runs mainly from the engineering department and out to the manufacturing and installation departments. There is little feedback until the task is carried out. Communication outside a work package happens only on rare occasions, for example if there is a disagreement between what is described in the work package and the real situation in the working area.

Since the engineering department is mainly working digitally and the manufacturing and installation department mostly working with a physical hard copy, there is a digital divide between

them. The working area and conditions offshore is a challenge as far as the hard copy is concerned. They get muddy and wet, and sometimes the hard copy is of poor quality which makes it even harder to read. Another challenge in the working area is that there is only one work package with updated information, which will be a major problem if it disappears. This divide between an analogue and a digital way of work leads to problems when performance of a task does not turn out according to plan. New certificates have to be generated and transferred to the work location and manually inserted into the work package. The fact that the work package does not allow two-way communication results in a situation of information asymmetry between the engineering department and the manufacturing and installation departments. Because of this digital divide there is no access to real time data across the departments, and direct communication between departments goes through telephone or video conference. The manufacturing and installation personnel have access to information systems, and video conferencing systems but they require that the personnel must leave their work place. According to Wenger (1998) the work package will be regarded as a boundary object, but not according to Carlile's (2004) definition, because the information principally flows in one direction. In this industry multiple companies work towards the same area, and the information asymmetry may also affect them if there is a gap between available information and the real situation.

As mentioned earlier, the work package contains a 3D-plot which is included in the work package to provide better visualization of the task. However, an engineer may see the task in a different way than the operator and pick a 3D-plot from a different angle than what the operator would have chosen. To overcome this challenge the operators have access to a 3D-model, but not from the working area. These 3D-models help minimizing the difference in context between the engineering departments and the two other departments, by giving a visual representation of the task, but would be far more useful if they could be reached while remaining in the working area.

Capabilities

The key capability of the hand-held devices is the potential for a real-time way of working. The hand-held devices can through their inherent mobile and connected ability enable access to the information systems for the workers in all of Fabricom's locations. Through this it will also have the potential to improve the existing work packages, communication and collaboration between the departments in Fabricom and remove the partially analogue and partially digital way of working. By bridging this gap, and allowing field workers access to real-time information and communication the digital flow of information throughout the organization enables a number of organizational changes within the company's work-processes and the sharing of knowledge. The display of relevant information can be customized and tailored to fit the needs of each project, or each worker. This can increase the availability and accessibility of relevant information compared to the paper-based work packages that exist today.

The real-time link through the hand-held devices will enable the user to access information and communicate in real-time with assets in the organization without having to leave the working area. This means the worker can draw on the knowledge and know-how of resources that reside in other geographical locations while remaining at the work-site. Combined with the communication capabilities it also enables the field worker and the engineer to collaborate through shared tools. When using the hand-held device the field worker can share technical drawings. Are there divergences between existing drawings and the actual situation in the work area? This sharing of data can be supported by live video and audio feed, and enable on-site troubleshooting and collaboration across geographical locations. The possibility to

collaborate through a shared work surface in real time enables them to faster resolve problems and conflicts that may occur in projects. A challenge in this matter is the integration of different ICT-systems to actually make relevant information available, accessible and reliable. This is a time consuming change process which needs support in the upper management as well as manufacturing and installation personnel.

Shared Understanding between Departments

Today there is an information asymmetry and lack of shared understanding between the departments within the organization. These problems are partly caused by the different views the departments have of what is to be achieved in a particular project. The engineering department has a broader understanding of the project, in contrast to manufacturing and installation personnel, who receive a work package, execute the specific task and then retransmit the work package. This might result in the manufacturing or installation personnel not having the same understanding of a technical drawing as the engineers.

A hand-held device might contribute a great deal to the problems of diversified understanding and we will now take a closer look at this. Fabricom may reap great benefits of having hand-held devices included in their daily work, because of the improved possibilities when it comes to communication and information flow. But a development process where all the departments have a close dialogue and the user demands are heard will be crucial for success (Orlikowski, 1992). This way of developing the device will also result in more flexible use of the device.

One key potential of implementation of hand-held devices is a shared understanding between the departments. The shared understanding can be achieved through the development of shared syntax and semantics between departments as an outcome from effective collaboration (Carlile, 2002, 2004). In having a better visualization of schematics and drawings it will give the manufacturing and installation personnel a better understanding of what the engineer has originally planned. If there are any questions regarding the work package a hand-held device will make it easier to communicate changes and comments between the departments. This collaboration element is one of the most important effects to come from the future implementation. Especially the real time factor is a major leap forward for Fabricom, since as of today there is a considerable 'time gap' when it comes to performing a task and reporting it back to the engineering department, and because it is contributing to improved understanding regarding the task performance. We would like to point out that this 'time gap' does not represent a problem for Fabricom's work processes, but rather a relevant area of improvement. When it comes to collaborative working Edwards et al (2010) mention that an indicator of success is when the operational site team and office support team are acting as a single team. This can be seen if the team takes part in regular small talk. In Fabricom's case the operational site team will be the manufacturing and installation departments, while the office support team will be the engineering department. We know there is a low degree of informal communication between the departments beyond the formal communication through the work package. The prime reason for this is the geographical distance between the departments, and the fact that the engineering department has a different work day and focus, than the manufacturing and installation personnel. In spite of this the different departments is dependent of each other's work performance. Building on Edwards et al's (2010) four elements to create 'shared situational awareness', we are going to relate these to our Fabricom case.

Shared Mental Model

An interesting finding was the discrepancy between how the members of the engineering departments thought the other departments would react to the notion of using hand-held devices, and how the departments actually felt about the possibility of using this kind of tool. Our informants in the engineering department uttered these statements about their coworkers in both the installation and manufacturing departments:

It is going to be challenging getting people to use the hand-held device. They like the way they work, and they do not like change. They want their work packages on paper.

However, when we interviewed personnel from the manufacturing and installation departments they were very positive to this kind of technical support. In fact, one of the workers said that they had already discussed how it would be to use similar solutions.

The way we work today [with paper based work packages] the drawings get dirty and wet. Sometimes we cannot even read what is written.

We see that the engineering department considers the manufacturing and installation departments as being unwilling to use hand-held devices, while in reality they are positive towards such devices. This may pose a challenge when it comes to an implementation of hand-held devices, because a shared understanding is needed already prior to the deployment and how such a process can contribute to information symmetry and shared understanding through work performance. If a development and an implementation process are to be successful the management team must understand and incorporate the needs and views of all those that will be affected by the implementation. If they use only the work package, or the opinions of one of the departments, as a basis for the development and implementation of new devices the management team may end up in a competence trap. (Carlile, 2004, Lewitt & March, 1988). It is important not to rely on what is believed to be their views, or needs, but instead include them in the process to ensure that the end users' needs are met. During our research we shared our findings with members of the engineering department. They were positively surprised that the views on hand-held devices in the other departments were closer to their own views than they had thought.

Carlile (2004) mentions the importance of sharing knowledge with the help of a common 'dictionary' which the different communities of practice can understand. It is of great importance that these communities develop a shared meaning in order to understand what is communicated. We uncovered that the technical jargon is quite similar between departments, some sort of industrial standardization that have come together from personnel turnover (Lewitt and March, 1988). The difference lies in the working atmosphere and geographical distance. There are indications that there is an important dependency between the departments when it comes to each departments work tasks, because they all work towards one common goal in the value chain (Giddens, 1984 as cited by Orlikowski, 1992). Because of each department's interests in their own work, we would like to separate between the important dependency and the missing dependency in each department's detailed routines. The engineering department does not have the interest, nor the qualification and skills to focus on the manufacturing department's detailed routines. The engineers design the drawings and the manufacturing departments perform their work according to these drawings. When the work runs smoothly it is hard to detect the differences between the departments. It is when there are issues that the differences show themselves (Bechky, 2003). In this case a physical object or visualization can be used to clarify syntactic and semantics differences as well as dependencies (Bechky, 2003, Carlile, 2004).

In today's work package the engineering departments adds 3D-plots of technical drawings as a compensation, and visual aid, to help the installation personnel in the understanding of the technical drawings. This is because they know it may be difficult to understand the drawings at times. However, it is still the engineer who picks which 3D-plot to add to the work package. A project manager told us that when they choose a 3D-plot it is easy to choose something that looks good in the eyes of the engineer, but a welder may have a completely different apprehension of the situation and therefore would like to view the plot from a different angle. In these cases it would have been useful with an interactive 3D-model and not just a 3D-plot. This is supported by an informant from the installation personnel. An offshore foreman said that the 3D-plots are not always sufficient and that it would have been helpful with an interactive model that could be manipulated according to the needs of the specific working situation. If installation personnel get an interactive 3D-model that they can carry with them out in the working area, they can get an even better understanding of what the engineer had in mind when he made the model and the drawings. In other words the two departments can come closer to a shared understanding of the task when they are assisted by a hand-held device.

Shared Real-Time Data

Presently all information is assembled in a work package and the introduction of a hand-held device would not change the basic working method to a great extent, because it still is the same tasks which is performed. The difference lies in: 1) how the information needed to perform a specific task is gathered, 2) how performed work is documented and 3) the possibilities for communication with the engineering department. All information previously described in the work package will be present in the hand-held device and stored in a central location. This will mean that the necessary personnel in the organization will have instant access to real time information in the same format. The organization will move from a manual transfer of information each way to a digital two-way communication. The personnel can use the work package/ hand-held device as an object for sending information, communicate changes and to produce documentation. The immediate effect of such implementation will be a reduced need for paper handling and the digitalization of the now manual paper work. After an implementation of a hand-held device the information will never have to leave its digitalized form.

In the scenario described above one would not need to actually produce a work package. They would only have to produce the data and the work package would be automatically ready for use. In a digitalized work situation the organization would save time and it will be easier to give feedback. Improving the work documentation would not only benefit Fabricom but also their customers who would receive better background information for decision-making. It is not only manufacturing and installation personnel who will notice major changes. Engineering and personnel further up in the organization will also gain benefits from this new communication channel. Nonconformity in models and drawings can be reported back immediately which gives a real time update. The hand-held device, if used correctly, can also improve the communication between the different departments because of the capabilities enabled by the technology (Carlile, 2004). The improvement consists of interactive communication between departments like video conferencing for visualization and discussion concerning a specific task, and also the personnel's possibility for working directly on the screen making the necessary inputs. This new way of communicating will result in a far more effective dialogue than previously.

Effective Leadership

Edwards et al (2010) propose that without effective leadership and upper management ownership, the "that would not work here" syndrome can be too strong to overcome. A sosio-material approach reminds us that the technology does not constitute the capability unaided. There are a group of personnel at three different departments in addition to Fabricom management and support as well as collaborating partners involved. The capabilities are constituted by all human and technical resources working together as a coherent solution. The vision has to be clear so that the technology designed, the conveyed messages, the developed competence and the communicated expectances are aligned. How to facilitate effective leadership have to be considered in all phases; planning, development, implementation, and further development of the hand-held device. In addition to clarity of vision, Edwards et al (2010), points at absolute integrity and honesty. Under-communicated problems might escalate if not handled. Challenging situations have to be discussed and prevented. For all change activities there are possibilities of counterforces that might exceed the supporting forces. Openness and inclusive discussions where all actors are involved in common meaning construction and reification processes (Wenger 1998) will help the development of new capabilities, flesh out the role of new technology and its consequences for practice. Shared reification and meaning construction increase the possibilities to establish shared situational awareness and a shared syntax to improve the collaboration between the departments. To succeed with hand-held devices Fabricom have to mobilize not only their internal network but external actors as well. Both customers and other collaboration partners have to be involved and want this development. In addition both the IT-vendors of today's ICT-solutions and ICT vendors supporting the systems needed for hand-held device have to be mobilized.

Trust

Trust is an important ingredient throughout the process. There has to be trust between the employees on a capability level, as they have to be certain that the work process continues as intended. Today the engineers must be able to trust the field engineer's capability to understand the technical drawings, and perform the installation accordingly. The field engineers also have to trust that the drawings made by the engineer are correct. When implementing hand-held devices, there are also other issues added regarding trust between the employees. Now both the engineer and the field engineer have to be able to trust the IT-system to mediate and support their work correctly. They have to be able to trust the validity, integrity and availability of the system. Meaning they have to be able to trust that the information they get is current, trustworthy and always there when they need it. This trust may be difficult to build, and is easily irradiated if the employees experience technical difficulties. The engineers in the different departments now also have to trust each other's capability to understand and interact with the hand-held device. There is a difference between being able to read and understand technical drawings, and being capable of editing and revising drawings. The feedback-loop enabled through the hand-held device is worth very little if the engineers do not trust the feedback they get.

This poses three trust issues one has to follow closely when implementing hand-held devices:

1. Trust in each other's capability to perform work as intended
2. Trust in the IT-systems capability to mediate information as intended
3. Trust in each other's capability to revise information as intended

Self-Synchronization

Previously we have discussed the elements needed to build situational awareness. According to Edwards et al (2010) this shared situational awareness builds 'self-synchronization' (see also Filstad, et.al in this book). This basically means that the manufacturing and installation personnel will operate as autonomously as possible, and plan and execute their tasks based on shared situational awareness. However there are some pre-conditions to make this happen.

Sufficient Understanding of Goals and Directions Enabled by a Coordination Process

With a higher degree of shared meaning between the communities of practice the understanding of the project and the tasks within this will increase as a result. As an example can a 3D-model help installation personnel visualize the end-product and it is therefore less demanding to produce and install the object as it was meant to be. The hand-held devices will make it easier to coordinate information between departments, given that the systems operate the way they should. With a lot of systems talking together, internally and externally, this is one of the major challenges. The personnel will achieve more independence because of this technology, since they have instant access to information they earlier would have had to acquire from the engineering department. We would like to point out that the independence factor is an organizational decision, but the technology arrange for this to happen. The leader group of Fabricom must want the personnel to be more independent and to resolve problems earlier handled in consultation with superiors. On the positive side this might give the engineering department more time to focus on their work, and the manufacturing and installation personnel more confidence in their respective working areas. It would also create a lower degree of coordination, under the condition that the new routines are memorized by all involved personnel. On the negative side it might lead to flaws in the construction work if the manufacturing and installation personnel are insecure in their own competence. They might do operations they normally would have consulted engineers about, and this might be a challenge in the transitional stage of the implementation process.

High Degree of Available Quality Information and Shared Situational Awareness

With access to real time information all departments will have a better decision basis and confidence in their work. Their increased ability to make the right decisions will be a result of high quality information. The biggest difference will be the conversion from hard copies to digital versions, where the digital version can withstand the rough weather conditions offshore, as well as giving more complete information regarding the task performance. An important factor regarding the quality of the information is the two-way information flow previously lacking. This will make the work package fulfill Carlile's (2004) definition of a boundary object, as well as Wenger's (1998) earlier definition. In a situation like this there will be a lower degree of information asymmetry between departments leading to a higher degree of shared situational awareness. This will help the personnel notice and understand the ripple effects of the actions they make during task performing, thus giving them a higher degree of self-management. It is important though, not to forget that even if the information is available at any time it still has to be interpreted before it can be used.

Necessary Skills and Competence at All Levels

A hand-held interactive information system will assist the manufacturing and installation departments in getting answers to task-related questions, giving them access to expand their competence.

This will make the engineering departments more of a decision making support group, releasing more time to work on engineering tasks.

Confidence and Trust in Managers, Colleagues, Information, and Equipment

One important aspect regarding the hand-held device is the ability to always have an updated version of for example an edited drawing. With today's hard copies one would suffer a great loss if an edited hard copy should be lost before the changes have been saved. With a digital solution all changes would automatically be saved, creating a back-up if accidents should happen with a device. This will make personnel in all departments more confident that all information is up to date and complete. Because of the current digital divide there are challenges regarding the access to new revisions of drawings. Because these are sent digitally offshore, situations may arise where the necessary personnel do not get hold of the revisions before much of the work already is performed. One installation foreman told us that this can be critical if the commissioning in the project is already running late. We would like to point out that minor complications are being solved without the need for new revisions, with the changes being marked up on the physical drawing. This information will not be available in Fabricom's digital systems until the work package is returned. This is an example of a situation where the information asymmetry is turned the other way around. With real-time two-way communication both of these information asymmetry problems would be gone.

The Evolution of Collaboration and Collaborative Environments

Fabricom might improve their collaboration and as a result of that gradually get better connected to other departments because of the regenerated work package/boundary object, which now takes shape as a hand-held device. It might act as part of a capability platform (Henderson, et al, this book) by affecting human skills, work processes, organizational change and technology. This can help the organization in the scaling process and in further improvement and innovation processes Edwards et al (2010). With the implementation there is a possibility that the collaboration practices at Fabricom today would become more explorative, because of the access to new technology with real time communication possibilities.

Because of the geographical distance between the departments they would be better served with better integration between them. Though it may be a long way to go from single asset support to synergy across assets, this is vital to Fabricom's case in the long run in order to have efficient relations between the different departments, and also with their collaborating partners (Edwards et al, 2010). This will help in the translation process between the departments, because they will interact in a closer way focusing on supporting the work performance. Hopefully this might contribute to set aside some of the existing communication challenges. In addition the relations with customers and suppliers might change as a result of capability based contracting models. It is quite important that customers and suppliers have the same communication possibilities and information access as Fabricom for the gains to be maximized, or else they will become a bottle neck in the contracting model.

The real time information sharing will give other departments better access to resources, because of the avoidance of the two week gap in the reporting loop, and will also give better support for business units. This will of course demand a great deal of effort and is defined by Edwards et al (2010) as a third generation collaborative environment. This may also cause a change in existing work practices and routines since more of the work will be consequence of collaboration between departments. Such major changes will

be demanding and time consuming, because it is not only the technological implementation that have to be done, but also organizational changes that comes as a consequence of arranging for the implementation and the management of the fully implemented solution. If it is done thoroughly it might lead the organization towards more future-oriented work situations.

Technical Pitfalls

While the hand-held device can contribute a lot to Fabricom's work processes, it will be a fallacy to think it will solve all of today's problems. We have found that the implementation of hand-held devices in Fabricom will present a technological challenge, as the existing IT-systems currently used in the organization, is a fragmented composition of more or less task- specific or department specific systems. These IT-systems often lack the ability to interface and exchange information with each other. This leads to redundancy in the information systems, and the need for the users to enter the same information in several places. Adding hand-held devices on top of the IT-platform as it is today will by our opinion lead to more problems than benefits. As the hand-held devices are a location-independent representation of the information already found in the IT-systems, the systems have to communicate with each other to be able to support the hand-held devices. Without this, the information provided through the hand-held devices may be incomplete, outdated or even unreachable. We can relate this to the stack-model (Henderson et al, this book). To be able to reach capabilities in the information and collaboration layer one has to ensure the deployment and stability of the foundation in the technology resource layer and the intelligent infrastructure. Like building a house, you have to ensure that the foundation is in place before you try adding the structure. In this case, adding hand-held devices without ensuring a stable ICT infrastructure and supporting processes would be like adding the roof before putting up the walls.

In order to successfully implement hand-held devices, there has to be a thorough review of the existing IT-systems in order to ensure their ability to interface with each other, and to ensure a mutual compatibility with the organization prior to implementing hand –held devices. Lack of governance, the right people and processes can also inhibit the organization from successfully reaching each layer in the stack-model just as much as lack of technology infrastructure.

There are also issues related to interfacing between Fabricom and their customers. Since there is little standardization in IT-systems throughout the oil-industry the IT-systems Fabricom choose to develop/implement have to be able to interface with their customers systems to ensure maximum benefits. Lacking the ability to share information seamlessly with the customers will greatly reduce the benefits of implementing hand-held devices for all parties involved.

Implementing hand-held devices will also require deployment of wireless infrastructure to obtain the benefits gained from full mobility of the hand-held devices. The most pressing challenge here will be deploying wireless infrastructure on offshore locations.

How the hand-held device is designed, how is it developed and how it is taken into use will be of great significance for the consequences such an implementation will have for Fabricom. Technology today have a great potential and therefore it is of great importance that the organization identify what gains and effects they expect from the implementation.

Fabricom have identified what effects they want from a hand-held device, through their work with Statoil on integrated operations. In our research we found out that end-users also wanted many of the same effects. Therefore it is important that the technical demands related to the hand-held device and complementary systems are fulfilled, as well as satisfactory adaptation by the end-users.

The technology has to be relatively simple and intuitive in use in order to make the training and change-over as easy as possible for all personnel. A shared syntax between the departments might help in this process (Carlile, 2004). It is also important to take into account the needs of all of Fabricom's departments, and not developing a system based on the needs of only one department. Development and implementation of new technology often take use of unaltered technology and change structures and routines to adapt to the new technology, but in this case it is crucial that the development takes place as an iterative process between developers and users (Orlikowski, 1992). We would like to point out that all these challenges are known to the organization, and the organization is conscious of the issues regarding information sharing, both internally in the organization and with regards to their customers. They are also aware that these issues have to be solved prior to, or as a part of the development and implementation process of hand-held devices.

CONCLUSION

Hand-held devices have the potential to change work practice and to develop collaborative relations across geographical, competence and organizational borders. Technical aspects such as real time data, 3D visualization, wireless access, and shareware applications enable work practices continually involving those relevant, independent of location, competence and organizational belonging. The opportunities are great. Hand-held devices might represent a considerably shift in both short time efficiency and long-term development. The technology has potential to both streamline the work processes and to strengthen the long-term development by facilitating communication and feedback between different competences and practices. From a process perspective (Barley 1986) we know that the technology is translated by the social actors, and the realization of new practices is a result of an ongoing interaction between people and technology. Implementations of hand-held devices need a process perspective to facilitate the development of attitudes, understanding and willingness among the practitioners to ensure realization of the opportunities. Using the notion of socio-materiality (Orlikowski 2008) both technology and human actors are understood as emerging entanglements that exists temporarily. As we have seen, after discussions of hand-held devices all informants from all part of the work process grew interested as they all could see exciting opportunities for their work. If shared situational awareness is achieved, self-synchronization might occur to establish appropriate work practice utilizing the opportunities of the available technology.

Our data does not allow us to be precise about the challenges to reach shared situational awareness in this case. What we have seen is that the way they spoke of the opportunities of hand-held devices matched between the departments, and as the hand-held devices was set on the agenda both constructions and operations were more positive and interested than the engineers thought they would be. Shared situational awareness facilitates self-synchronization in a way that the new practice related to the hand-held devices is assumed to emerge similarly in the three departments. The key to development of new practice is then the shared situational awareness, operationalized by Edwards et al (2010) to shared mental model, shared real time data and information in the same format and an effective dialog, effective leadership, and trust.

The work package as a boundary object will fulfill its function as long as the work process progresses as planned. But when the work process deviate from what is planned, the work package can be interpreted differently by the involved parties. Lack of feedback will have the consequence that a shared understanding between departments will not be achieved. Real time data, feedback loops or more groups working with the work package at the same time make the work package function as a boundary object as any changes in interpre-

tation of the work package might be registered in the accessible 3D-model and influence the others interpretation as well. The digital divide will gradually be phased out, as the organization moves over to work digitally in all departments.

A change towards more collaborative environments sets high demands with regard to shared understanding of each departments work situation and the availability of updated information. By using a capability approach and relating the capabilities to a stack-model, the organization can ensure a stable foundation and add to the stack layer by layer. It is crucial that the management team supports the change process wholeheartedly and creates trust between departments, as well as being aware of possible pitfalls

REFERENCES

Bechky, B. A. (2003). Sharing meaning across occupational communities: The transformation of understanding on a production floor. *Organization Science*, *14*(3), 312–330. doi:10.1287/orsc.14.3.312.15162

Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. Cambridge, MA: MIT Press.

Callon, M. (1991). Techno-economic networks and irreversability. In Law, J. (Ed.), *A sociology of monsters, essays on power, technology and domination* (pp. 132–165). London, UK: Routledge.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455. doi:10.1287/orsc.13.4.442.2953

Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science*, *15*(5), 555–568. doi:10.1287/orsc.1040.0094

Edwards, T., Mydland, Ø., & Henriques, A. (2010*). The art of intelligent energy (iE) – Insights and lessons learned from the application of iE*. Society of Petroleum Engineers.paper 128669. Paper presented at SPE-conference Intelligent Energy, Utrecht, February

Giddens, A. (1984). *The constitution of society*. Cambridge, MA: Polity Press.

Iyer, B., & Henderson, J. C. (2010). Preparing for the future: Understanding the seven capabilities of cloud computing. *MIS Quarterly Executive*, *9*(2), 117–131.

Levitt, B. A. (1988). Organizational learning. *Annual Review of Sociology*, *14*, 319–338. doi:10.1146/annurev.so.14.080188.001535

Monteiro, E., & Hanseth, O. (1996). Social shaping of intormation infrastructure: On being specific about the technology. In Orlikowski, W. J., Walsham, G., Jones, M., & DeGross, J. I. (Eds.), *Information technology and changes in organizational work* (pp. 325–343). London, UK: Chapman & Hall.

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science*, *3*(3), 398–427. doi:10.1287/orsc.3.3.398

Orlikowski, W. J. (2008). Sociomateriality: Challenging the separation of technology, work and organization. *The Academy of Management Annals*, *2*(1), 433–474. doi:10.1080/19416520802211644

Orlikowski, W. J. (2009). The sociomateriality of organizational life: Considering technology in management research. *Cambridge Journal of Economics*, *34*, 125–141. doi:10.1093/cje/bep058

Postholm, M. B. (2005). *Kvalitativ metode: En innføring med fokus på fenomenologi, etnografi og kasusstudier*. Oslo, Norway: Universitetsforlaget.

Raymond, L., St-Pierre, J., Fabi, B., & Lacoursière, R. (2010). Strategic capabilities for the growth of manufacturing SMEs: A configurational perspective. *Journal of Developmental Entrepreneurship*, *15*(2), 123–142. doi:10.1142/S1084946710001476

Shannon, C., & Weaver, W. (1949). *The mathematical theory of communications*. Urbana, IL: University of Illinois Press.

Weeks, M. (2009). Sourcing practices and innovation: Evidence from the auto industry on the sourcing relationship as a dynamic capability. *Innovation: Management. Policy & Practice*, *11*(3), 304–326. doi:10.5172/impp.11.3.304

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Zonooz, B. H., Farzam, V., Satarifar, M., & Bakhshi, L. (2011). The relationship between knowledge transfer and competitiveness in "SMES" with emphasis on absorptive capacity and combinative capabilities. *International Business and Management*, *2*(1), 59–85.

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Section 5
Leadership and Learning

Chapter 16
Adaptive Advisory Systems for Oil and Gas Operations

Andreas Al-Kinani
myr:conn solutions, Austria

Nihal Cakir
myr:conn solutions, Austria

Theresa Baumgartner
myr:conn solutions, Austria

Michael Stundner
myr:conn solutions, Austria

ABSTRACT

This chapter describes a framework that captures knowledge in an organization and applies it in daily operations. Knowledge capturing is one of the biggest upcoming challenges to oil and gas organizations as operations become more remote, more challenging, and many experts are leaving the oil and gas industry. A methodology is described to capture the knowledge of experts centrally and apply it throughout all operations in the organization. Due to the fact that an asset team is facing different constraints and challenges throughout the lifetime of a field, the system needs to gather experience from decisions and learn together with the asset team. Technologies that are flexible enough to process uncertainties are discussed as well as the effect on people, processes, and organization.

INTRODUCTION

Many oil and gas asset teams nowadays face increasing challenges in daily operations due to strict production targets imposed by the economic objectives of their organization. Asset teams have to strive for lean and efficient technologies and processes to maintain or increase production and at the same time maximize profits. Maintaining a high level of production requires complete asset awareness and hence occupies a significant amount of an asset's resources.

A typical asset team is confronted with several challenges on its way to efficient production operations. An increasing amount of sensors in the

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field delivers more and more data. Maintaining control over the data flood in fields with many sensors and high frequency data may turn out to be a very challenging endeavor. Furthermore it requires fully accessible personnel on site that is skilled enough to detect performance problems in the field at a very early stage, to analyze those problems in a short time frame and to suggest activities to correct the issues. Very often these experts and their highly valuable knowledge are not available at all times and hence the asset team needs to solve issues without the input of the organization's experts.

This challenge is even more pronounced when taking a closer look at the age distribution of petrotechnical professionals in the oil and gas industry. According to Rostand and Soupa (2011) the *Big Crew Change*, a phenomenon according to which about 5,000 experienced petrotechnical experts are about to leave the oil and gas industry due to retirement by 2014, will seriously challenge oil and gas companies in their knowledge retention efforts. The resulting demographic shift will not only reduce the number of experts in every organization, it will also very likely lead to the loss of tremendous amount of experience and knowledge and ultimately will increase the risk of not maintaining current production levels. The challenge is even aggravated by the rising need to produce hydrocarbons from more remote and more complex reservoirs. The authors emphasize that in order to ensure unhindered production growth the industry will have to manage the handover from retiring petrotechnical professionals to the new generation as effectively and smoothly as possible.

Simply having enough workforce does not necessarily mean that the expertise is maintained in the industry. Constant knowledge capturing and transfer is necessary in order to increase an organization's knowledge and not to stagnate or even decrease. While the industry is running the risk of not attracting enough talented young petrotechnical professionals to maintain the available expertise in the industry, it is very important to not only approach the knowledge retention challenge through people, but also through technology (such as workflow standardization and knowledge capturing) and organizational changes (such as outsourcing knowledge intensive work to internal or external competency centers) to support or enhance production efficiency.

Hite, Crawley, Deaton, Farid and Sternevsky (2007) discuss in their paper how 91% of participants in a survey conducted by the SPE Real Time Optimization Technical Interest Group spend more than 50% of their time looking for, accessing and preparing data, which ultimately leaves less than 25% of their professional time for analysis as well as for evaluation of operational options and decisions. Based on this work Brulé, Charalambous, Crawford and Crawley (2008) proclaim in their paper how "faster decisions with precision have tremendous value, and provide much leverage in any industry hindered by a shortage of qualified people".

The Digital Oilfield initiatives started to tackle some of the workflow standardization challenges by automating repetitive yet time consuming and error prone tasks, such as the data transfer from the sensors in the field to the desks of the engineers and partially the data preparation (Brulé et al., 2008). In some projects even more complex workflows including simulation models and optimizers were automated, which freed the asset team to put increased focus on value adding activities such as root cause analysis and production optimization (Brulé et al., 2008; Sagli, Klumpen, Nunez, & Nielsen, 2007; Stundner, Nunez, & Møller Nielsen, 2008).

However, in order to not only streamline production processes but whole decision making processes, many asset teams are looking for the right technologies to capture, continuously update and apply knowledge of skilled personnel. A demand to move from pure *Information Technology* (IT) to *Knowledge Technology* to better leverage the available expertise is generally observed in the petroleum industry. As presented in this

chapter, knowledge capturing technologies can not only enable asset teams to automate repetitive processes, but also to automate complex decision making processes that typically would involve many experts from various disciplines.

In contrast to conventional batch processes (e.g. as in a factory or in a car race where processes and activities are repeated and hence become comparable in every loop) reservoir management cannot be considered a repeatable process. Conditions in the reservoir change continuously as liquids and gas are produced. During the life of a field operational constraints that limit the production potential may change or even disappear completely while new constraints may come up. Production from a greenfield for example is typically constrained by available facilities such as the number of wells or surface installations, while brownfields are mostly constrained by the deliverability of the reservoir or the processing capacities of the facilities (e.g. water handling). The general environment and rules of operations constantly change as production continues. This is why it is very challenging to standardize and maintain workflows and processes in a petroleum asset over the lifetime of a field. A system that supports people and processes in day to day decisions needs to adapt to ever changing conditions, which means that it has to be able to learn and gain experience with the asset team during production operations.

This chapter describes a concept, framework, and a proposed system allowing companies or teams capturing the knowledge available in their organization independent of domain discipline or geographic location. The chapter discusses the basics of knowledge theory and suggests appropriate technologies, approaches and workflows to capture an organization's knowledge, maintain and adapt it and apply it in ongoing operations. The objective is to create a system that is not only capable of monitoring oil and gas production operations but also to support engineering personnel with day to day decisions and impact evaluation including the follow up of decisions to enable and facilitate learning and improvement. Ultimately the objective is to increase or maintain the hydrocarbon production level and to remove the burden of repetitive tasks from the engineers in order to enable focusing on value adding activities such as production optimization or reservoir management and planning.

BACKGROUND

The terms data, information and knowledge are an integral part of our general linguistic usage. Their meanings are obvious to all of us, but when it comes to integrated adaptive systems a clear definition and proper distinction is necessary, since data, information and knowledge are processed in different ways.

According to Russell Ackoff (as cited in Bellinger, Castro, & Mills, 2004) the content of the human mind can be classified into five categories:

- Data are non-interpreted signals, characters, patterns, codes, etc. that have no prior meaning for the agent, i.e. the human or the machine. Data simply exists and has no significance beyond its existence (in and of itself). It can exist in any form, usable or not.
- Information is data that has been given meaning by way of relational connection. This meaning can be useful, but does not have to be. Information provides answers to "who", "what", "where", and "when" questions.
- Knowledge is the appropriate collection of information, such that its intent is to be useful. It gives answers to "how" questions. Knowledge is a deterministic process. When someone memorizes information, then they have amassed knowledge. This knowledge has useful meaning to them, but it does not provide for, in and

of itself an integration such as would infer further knowledge.

- Understanding is the appreciation of "why". Understanding is an interpolative and probabilistic process. It is cognitive and analytical. It is the process by which you can take knowledge and synthesize new knowledge from the previously held knowledge. The difference between understanding and knowledge is the difference between "learning" and "memorizing". People who have understanding can undertake useful actions because they can synthesize new knowledge, or in some cases, at least new information, from what is previously known (and understood). That is, understanding can build upon currently held information, knowledge and understanding itself. In computer parlance, artificial intelligence systems possess understanding in the sense that they are able to synthesize new knowledge from previously stored information and knowledge.
- Wisdom is evaluated understanding. Wisdom is an extrapolating and non-deterministic, non-probabilistic process. It calls upon all the previous levels of consciousness, and specifically upon special types of human programming (moral, ethical codes, etc.). It beckons to give us understanding about which there has previously been no understanding, and in doing so, goes far beyond understanding itself. It is the essence of philosophical probing. Wisdom is therefore the process by which we also discern, or judge, between right and wrong, good and bad. Wisdom is a uniquely human state.

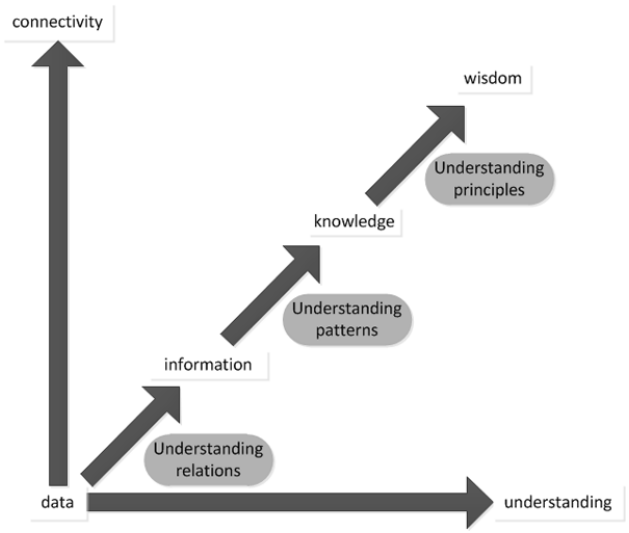
Bellinger et al. (2004) contend that the sequence is less involved than described by Ackoff. Figure 1 represents the transitions from data, to information, to knowledge, and finally to wisdom, and it is understanding that supports the transition from each stage to the next. Understanding is not a separate level of its own.

There are two types of knowledge according to Nonaka and Takeuchi (1995). Explicit knowledge can be expressed in formal and systematic language. It can be processed, transmitted and stored relatively easily. In contrast, tacit knowledge is highly personal and hard to formalize. It is difficult to communicate to others. Nonaka and Takeuchi (1995) emphasize that tacit and explicit knowledge are complementary. Explicit knowledge without tacit insight quickly loses its meaning. Knowledge is created through the interactions between explicit and tacit knowledge, which are:

- Socialization (from tacit to tacit): tacit knowledge can be acquired only through shared experience.
- Externalization (from tacit to explicit): when tacit knowledge is made explicit, knowledge is crystallized, thus allowing it to be shared by others, and it becomes the basis of new knowledge.
- Combination (from explicit to explicit): explicit knowledge is collected from inside or outside the organization and then combined, edited or processed to form new knowledge. The new explicit knowledge is then disseminated among the members of the organization.
- Internalization (from explicit to implicit): is closely related to "learning by doing". Explicit knowledge has to be actualized through action and practice.

While not widely applied, knowledge capturing systems have a long history. Scientists such as Newell and Simon (1972) have devoted a significant amount of research to problem solving strategies used by humans. Stanford University has conducted a research project to implement an expert system for the diagnosis of infectious diseases, called MYCIN (Buchanan & Shortliffe, 1984).

Figure 1. Transition from data, to information, to knowledge, to wisdom, with understanding supporting the transition



Their implementation was built on the premise that the reasoning engine needs to be detached from the knowledge representation, which is why they introduced a so called *knowledge base* into their system enabling the expert system to draw decisions and detaching the inference engine from the knowledge container. According to Buchanan and Shortliffe (1984) "The knowledge base is constructed from knowledge that is obtained from domain experts by knowledge engineers and/ or from statistical data contained in a database." They hence introduce a clear distinction between the database that contains the data and the knowledge base that contains the knowledge.

Operational Business Intelligence in Production Operations

Business intelligence (BI) is the combination of practices, capabilities and technologies that companies use to gather and integrate data, apply business rules and deliver visibility to information in order to better understand the business and ultimately improve performance. Operational BI is the application of business intelligence capabilities within operational areas of the business that typically involve information and data that changes frequently during the business day (Hatch, 2009).

In the context of oil and gas production, operational business intelligence summarizes all activities and technologies that lead to a better asset awareness and will hence assist the asset team in their decision making processes. This includes data integration systems, workflow automation, reasoning systems and reporting tools such as web dashboards.

There are four steps in related decision making processes to produce hydrocarbons from an asset in an optimized way:

Step 1: Free to Focus: Data Screening (e.g. special visualization, data mining) is used to identify symptoms that show where asset performance is not as good as expected. Patterns among wells are detected in order to identify similar behavior and reduce the complexity of the screening problem from several hundred sensors to a few categories of similar measurement types.

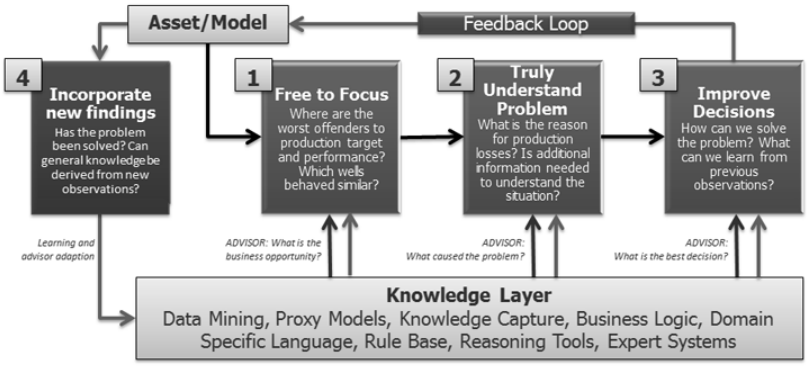
Step 2: Truly Understand Problem: Petrotechnical analysis methods (e.g. sensitivity analysis, numerical or analytical models, etc.) are applied to identify the root cause of why the performance is below expectation. The objective is to identify the constraint, such as whether the liquid production is limited by reservoir deliverability, by well production potential or by facility processing limits. Due to the ambiguity of some of the symptoms as identified in step 1 the outcome of step 2 will be probabilistic indicating most likely causes, but also possible alternative causes.

Step 3: Improve Decisions: Based on a definition of utility (e.g. maximize production, minimize losses, increase net present value, reduce lost time, etc.) decisions are suggested to solve the problems as identified in step 1 and 2. Previous experience from the same reservoir or from similar situations in other reservoirs or from case studies are the sources to select the most promising action with regard to the utility, given the constraint as identified in step 2. A definite selection will not be possible in this step. Therefore the suggestion will be of probabilistic nature.

Step 4: Incorporate New Findings: The impact of the actions resulting from the decisions in step 3 is analyzed and verified. Did the action yield the expected results or is the performance different from what is expected? The discrepancy between the expectation and the actual observation is the learning opportunity, which needs to be recorded, explained and finally generalized to clearly identify, whether this particular piece of information is applicable to a single situation, to the whole field or to the whole company. The gained knowledge is stored and updated in the knowledge layer for future application.

The authors' previous experience has shown that companies hardly ever approach this decision framework systematically. A series of individual, non-connected processes are executed on individual workstations or desktops instead and the effort to integrate the measurements and information to allow for a holistic view on reservoir management is typically exceeding the resource capacity and time frame of typical asset teams. Especially the fourth step in Figure 2 - Incorporate New Findings - is very seldom in place, i.e. the *Feedback Loop* if a decision was good and how to improve future decisions is missing. This concept of feedback to actions of the system however is one of the cornerstones of reinforced learning to improve reasoning systems. Mitchell (1997) states that one key attribute in the design of a learning

Figure 2. Operational business intelligence concept applicable to hydrocarbon production operations



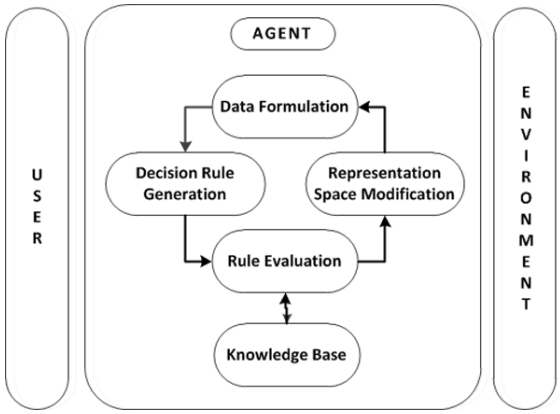
system is whether the training experience provides direct or indirect feedback regarding the choices made by the system.

It is surprising that little efforts have been taken so far to standardize and capture the knowledge involved in reservoir management processes in a corporation-wide expert system, which is able to learn and improve implemented rules. State of the art machine learning techniques allow not only to capture knowledge, but also to improve the decision making process and even recover from incorrect knowledge (Sartika & Suwardi, 2007). In a system that is self-adaptive in nature, the learning process consists of a combination of experience and theory (i.e. prior knowledge) thus resembling human learning. The advantage of such a system is that it cannot only learn from one individual user, but simultaneously from all users and modeling processes, which are controlled by the system. Therefore the learning process and hence the expert system's improvement are steadily and faster increasing than in any reservoir management effort performed by an individual petrotechnical expert (Zangl, Al-Kinani, & Stundner, 2011).

The schematic of an architecture for a constructive induction-based learning agent (Bloedorn & Wnek, 1995) is shown in Figure 3. In this architecture the agent acts as an interface to the environment, i.e. the reservoir management processes. The system has two modes, the passive or 'monitoring' mode and the active or 'learning' mode. In its passive monitoring mode the agent records the actions of the user dealing with the environment as described in step 3 of Figure 2. In the active learning mode, the agent learns the useful skills from the interaction with the user. The user interaction is recorded and validated as described in step 4 in Figure 2 and hence allows the agent to improve its decision support performance without the necessity of dedicated involvement of the user. The information status of the agent's current understanding of the problem is stored in the knowledge base. The contents of the knowledge base can be updated e.g. by a constructive induction learning algorithm or by direct user input overwriting stored values. According to Zangl et al. (2011) the representation space modification module may add or remove a new information and general knowledge (e.g. new or altered relationship between tubing head pressures and well performance).

The possibility to influence or 'teach' the system, throws a very different light on the ownership of knowledge and workflows in an organization compared to what conventional business workflows do. Production management workflows are typically centrally deployed, very often with little or no possibility for engineers in an asset to suggest technical issues such as particular performance indicators or special business rules. The acceptance of these centrally deployed workflows hence is typically very low as asset teams feel that the workflows and performance metrics are imposed to the asset team from the IT department or management, without any particular applicability for the asset team's reservoir and very special challenges. The learning layer approach however will give every user the possibility to participate in making the system stronger and share knowledge, which is thought to increase job satisfaction

Figure 3. The architecture of a constructive induction-based learning system (Bloedorn & Wnek, 1995)



and production efficiency (Miller & Monge, 1986). By learning from the asset team, the expert system will be able to capture also very specific logic that is important for a particular business unit or asset team. The responsibility of maintaining and building knowledge as well as the success of the expert system is handed to each engineer in the whole technical community of an organization, with the opportunity to participate and share for everyone (Behounek, 2003).

Knowledge Capture Using Bayesian Networks

Bayesian Networks are a powerful tool for knowledge representation and capturing in complex systems under uncertainties (Mitchell, 1997). The transparent structures of Bayesian Networks allow inferring roots of problems and influences of evidences on utilities and decisions - features that facilitate the user acceptance and trust. While other, mostly data driven, approaches very often act as black boxes, with little possibility for the user to truly understand the presented information (Zangl & Hannerer, 2003), Bayesian Networks are the ideal amalgam of a data driven method and an expert driven method, allowing to mine through large amount of data while still being able to explore the inherent relations and findings. Bayesian Networks have the ability to learn from observations. They include these findings either as changes in the network's structure (which corresponds to changes in the cause - effect relationship) or as changes in the logic representations (which corresponds to changing the weight of different observations). This enables smart, flexible and adaptive systems as they are needed in reservoir management processes.

The basis of the Bayesian Network is the Bayes' theorem, which states that the belief in a certain proposition (prior probability) is modified as new evidences pro or contra this proposition are encountered. The result is the posterior probability, the belief in a certain proposition under consideration of all available evidences.

In mathematical terms this reads as:

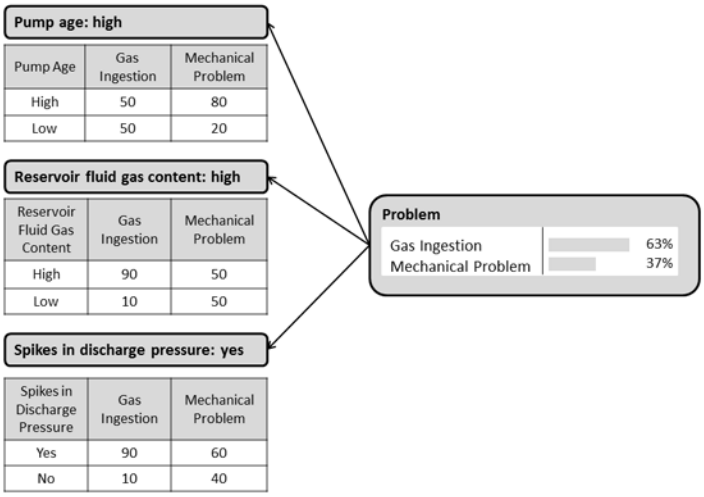
$$P(H \mid D) = \frac{P(D \mid H) \bullet P(H)}{P(D)}$$

where

- P(H) is the prior probability that the hypothesis H is true
- P(D|H)/P(D) is the conditional probability of seeing the data D given that the hypothesis H is true
- P(H|D) is the posterior probability, the degree of believe in H after D is observed

A simple example from the oilfield is depicted in Figure 4. An electrical submersible pump (ESP) that is used to lift liquids from the wellbore to the surface shows a significant drop of liquid rate. Assuming that there are only two possible causes for this performance drop, the prior probabilities that a 'mechanical problem' $P(H_1)$ or 'gas ingestion' $P(H_2)$ may be the possible reasons are equally high. The pump is very old $P(D_1)$, and the fluid in the reservoir is known to contain a significant amount of gas $P(D_2)$. These evidences do not allow to infer the most likely reason according to the expert knowledge stored in the conditional probability tables of the Bayesian Network. The experts cannot be sure which of the two causes is the reason for this particular drop in ESP performance based on these two evidences only. They need additional information. Observing the real time data from the pump (e.g. spikes in discharge pressures) $P(D_3)$ confirms the belief that the reason is 'gas ingestion'. The posterior probability of this scenario $P(H_2|D_1$ and D_2 and $D_3)$ is much higher than in the 'mechanical problem' scenario $P(H_1|D_1$ and D_2 and $D_3)$. The most likely cause for the pump failure is hence identified, taking into

Figure 4. Simple Bayesian network. The boxes on the left (pump age, reservoir fluid gas content, spikes in discharge pressure) are used to enter the observations and the tables represent the conditional probability containing the expert knowledge. The output 'problem' is computed using the conditional probability tables in combination with the observations.



account all evidences (D_1 to D_3), the data and the expert knowledge about the fluid composition. The saved time and money may be significant as the remedial action in a 'gas ingestion' case is to increase the pump frequency while a 'mechanical problem' may very often require the change of the whole pump.

When constructing a Bayesian Network, we have to differentiate between actually observable variables and the physical reality that is unknown. In order to better model the physical reality, *non-observable* or *hidden variables* are included in the network. An example for a hidden node in a similar Bayesian Network may be the reservoir pressure, which is a function of the depth and the geological properties around the wellbore, but cannot be measured directly (Woolf, 2009).

The example in Figure 4 shows, that in contrast to purely data driven artificial intelligence tools, Bayesian Networks are the preferable expert system in reservoir management workflows because:

- They are fully transparent and turn implicit knowledge through a quantification of the reasoning logic and a graphical representation into explicit knowledge. They are hence a great tool for communicating uncertain and imprecise knowledge to other experts and are therefore a great enabler of collaboration in teams.
- They are capable of doing reasoning under uncertainty, which corresponds much more to the way a human being does reasoning. Observations are usually expressed probabilistically than deterministically, such as 'The gas content in the reservoir fluid is rather high.' Deterministic and rule based explanation tools, very much in contrast to Bayesian Networks, will have difficulties combining the imprecise information from various sources under a common, consistent and unbiased reasoning umbrella.
- Gaps, imprecise or even wrong measurements do not impair the inference ca-

pabilities of the Bayesian Networks, as it – lacking any hard or reasonable facts (measurements) – assumes the most likely value based on the formulation of prior probabilities.

- The reliability of expert systems based on Bayesian Networks is very high. The computation of posterior probability is quick and can be performed in a stable manner, even in combination with larger workflow systems in distributed systems (e.g. in a large IT environment).
- The stored logic in a Bayesian Network is adaptable by various learning algorithms or through manual intervention. It can hence be modified incrementally whenever new pieces of information, such as new observations, are available that are significant and generalized enough to be included in the expert system.
- Due to the structure of Bayesian Networks it is possible to very easily combine the knowledge of experts from various domains. While conventional decision making in asset teams is typically very isolated with every domain experts drawing decisions based on their relevant evidences only, Bayesian Networks enable the integration of all this expert branches under a joint decision support system, which enables consistent screening and interpretation of evidences.

Above statements make Bayesian Networks an ideal reasoning and explanation engine in automated but human centered workflows. While automating repetitive and obvious tasks, the human expert is still consulted if the situation demands clarification. This approach is a necessary concept to assist oil and gas field operation tasks in an optimal way by supporting the asset team where possible and giving full responsibility and flexibility to the asset team, when human expertise is necessary to integrate all information, impressions and experiences. Using Bayesian Networks as the reasoning engine, the workflows can be processed fully automated, while only requesting user guidance during ambiguous situations or when additional information is needed to draw a more definite decision.

Construction of an Expert System

The initial construction of the Bayesian Network should be conducted in four steps (Van Gerven, 2007):

1. Variables are the nodes of the network; they can either be chance, decision or utility variables. Along with the category, the type and state of the variable have to be defined. The type of a variable refers to its nature being either discrete with mutually exclusive states, or continuous. In practice it is easier to start with a simple initial model, carefully selecting variables according to its importance and then in a next step adding other variables, until the model is accurate enough.
2. The structure of the model ideally mirrors the physical reality of problem causalities. Experts can use their own knowledge and previous experience, textbook knowledge and in some cases even learning data to set up the structure. Starting off with a simple model and gradually increasing the complexity and adding small domain fragments will ensure the functionality of the model. In case of the advisor, the steps of identifying an opportunity, investigating the root cause, and support the decision should be set up as individual systems and then being integrated in a next step.
3. Factor association refers to the relationship between parent variables and child variables. A factor defines the functional form of how the outcome of the random variable of the child depends on the state of its parents.

4. Parameter estimation can be carried out in three different ways. The easiest and most accurate way is to make the network learn the probabilities from sufficiently large and good quality training datasets. However, a suitable dataset is very often not available. In this case experts estimate the probabilities based on their previous experiences within a certain technical aspect of the advisor. The third option is to derive probabilities from literature. The probabilities are adapted automatically in the online mode of the advisor.

THE ADAPTIVE ADVISORY SYSTEM

Operations in oil and gas fields are typically driven by the objective to maximize ultimate recovery or the recovery to a certain date. Production losses mean that a significant amount of money is left on the table. Hence deferred production or underperformance must be detected as soon as possible after occurrence (or ideally even before it occurs) and an activity needs to be initiated immediately to reduce the amount of lost production or to avoid any losses at all.

The business need to detect events such as severe underperformance in the asset and react properly as timely as possible in order to keep production up to the target combined with the incomplete and uncertain information available from the sensors in the facilities and wells leads to the fact that operations are very often merely firefighting and rushing from one event to the next. Actions are usually taken reactively after a certain event has been observed. Moreover, the actions that are considered after a certain event has been detected are very often not based on the full amount of technical expertise available to an oil and gas producing organization at a current time but rather on typical approaches and rules of thumb that have been around in an organization for ages.

Standardization of processes, common performance metrics, reporting and documentation is hardly ever in place. Hence it becomes difficult for an organization to monitor and support their producing assets and almost impossible to efficiently share information from one organizational unit to the next.

The Adaptive Advisory System is designed for an intensive interaction. It captures knowledge from experts and experiences and at the same time provides a framework for an intensive knowledge exchange of engineers, experts and managers. It facilitates the asset team in decision making processes and helps to file knowledge in a way that it is accessible in future times as well as to other units.

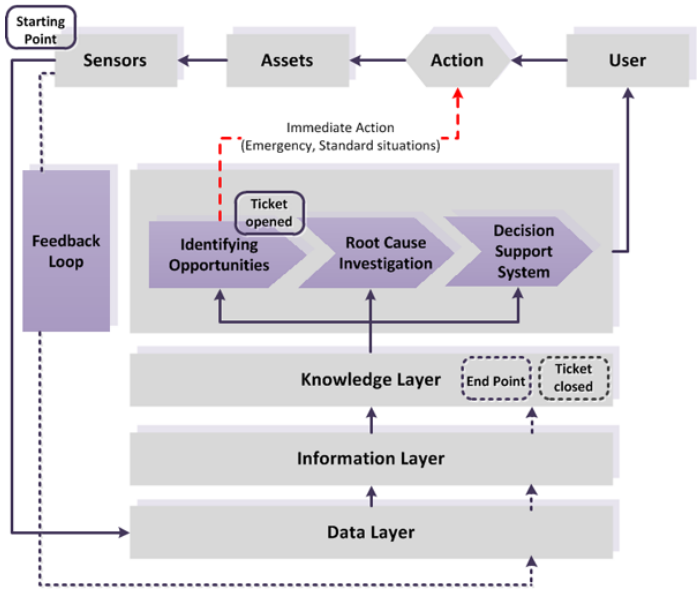
In real time operations, processes consist of acquisition, preparation and storage of data, a technical analysis, a business analysis and finally a recommendation for a concluding action (Hite et al., 2007). The advisor integrates the complete process into one single system.

The Adaptive Advisory System is displayed in Figure 5. It includes three layers, the *Data Layer*, the *Information Layer* and the *Knowledge Layer*. The knowledge layer is the backbone of the advisor, which applies the captured knowledge by feeding the four main elements, needed to identify opportunities, analyze the root causes of these opportunities, support the decision making process and help the asset team to learn from new measurements by evaluation and validation of decisions within a feedback loop.

Human actors are an integral part of the Adaptive Advisory System. It should not be seen as an intelligent machine replacing engineers and experts, but as a knowledge sharing enabler: the system learns from its users and users learn from the system.

The term *user* refers to all personnel interacting with the system. Users can be engineers, experts or managers. *Experts* are engineers or scientists with a more profound knowledge on either specific areas of oil and gas operations

Figure 5. System overview of the adaptive advisory system



(geologists, drilling engineers, etc.) or generalists, who have aggregated a lot of experience with an asset, including error-proneness of tools and other peculiarities. The knowledge of different experts is required to initially set up the system for the determination of causal relationships, for checking the plausibility of probabilities learned from data and for estimating probability values and utilities. *Managers* interact with the system if it provides several alternatives with a similar utility value; they or any other decision committee makes the final decision if the results are ambiguous. The Advisor additionally provides business key performance indicators and other important indicators.

One of the most important principles in alarm and event management is that each event requires an *action* to be taken that causes a change in the *asset*. For organizational and tracking purposes a ticketing system may be introduced to track open issues and make sure that new issues are tracked and monitored more closely. The ticket shall monitor and document all decisions and activities with regard to the identified event. This enables the asset team to be able to query the event and all associated activities at a later point in time and also to present experience from past tickets in combination with newly occurred problems. Since the presented advisory system is highly dependent on feedback of the success of the taken decisions, a ticket needs to be kept active until a proper evaluation has taken place that consistently screens the performance of the asset after the actions of the asset team.

The term asset is used in a broad sense and can refer from a single machine, a well, a group of wells, an offshore platform, a field, a reservoir, an underground gas storage plant, a production plant, etc. to the whole production system of a company.

Components of the Adaptive Advisory System

The Data Layer is a database that integrates data from various sources, in various time sequences and in various formats. Next to historical data, newly generated real time data as well as activities in the asset (e.g. maintenance orders, changes of operational settings, etc.), events, problems, recommendations and final actions are stored and

accessible any time later. The Information Layer fulfills two purposes: Firstly, it closely interacts with the data layer and generates information from the data, calculates or models trends, key performance indicators and thresholds. Secondly, the Information Layer provides a link to external applications such as reservoir or production modeling software and external databases such as an accounting data base. The Knowledge Layer contains the knowledge representation, the backbone for the Bayesian Networks that allows the advisor to learn and adapt. The advisors will be described in detail including the underlying methods and examples for demonstration purposes.

Identifying Opportunities

The first step of the advisor, as presented in the operational business intelligence concept (Figure 2), is to identify, which parts of the asset are not performing up to their expectation or situations, where the defined objective of an operation is running risk not to be achieved. This step hence needs to detect all situations that require further activity either by the human users, or by the subsequent reasoning process. Those situations are referred to as *Events*. An event is an expected or unexpected occurrence that is unusual relative to normal patterns of behavior (Kerman, Jiang, Blumberg, & Buttrey, 2009). This step can very often be achieved through deterministic business rules, notifying the system about violations of operational limits, such as too high vibration in the pump or too high concentrations of H_2S.

Many challenges exist in event detection. Two events are hardly ever exactly the same, a circumstance, which is referred to as *situational dependence*. Complex systems require similarly complex event detection mechanisms. The goal of event detection is to reach a high true positive (correctly detecting an event if it occurs) rate and a low false positive (wrongly detecting an event that did not occur) rate, which demands a high degree of precision and timeliness. The Event Detector is closely linked to the Problem Classifier to which it provides inputs.

There are two cases, where the advisor takes immediate action without human interaction: emergencies and standard situations, where no further action is required. The event detection step is designed to identify *alarms*, which are events with a high urgency and require immediate action. In case of an *emergency* (i.e. if certain predefined thresholds are exceeded), the user is alarmed and actions that influence the assets (e.g. shut down) are triggered automatically to keep the damage as low as possible. For *standard situations* that have occurred frequently in the past or planned events (e.g. production stop due to maintenance work), the resulting problems and decisions are well known and approved; to save time and reduce the workload of engineers, the actions can be executed automatically.

Root Cause Investigation

Investigating the root cause of events involves further analysis of the available evidences and possibly the request of additional evidences. The outcome of the root cause investigation is a definition of the problem that has occurred in the asset. Therefore it is a very analytical step, where the user is requested to interact with the system and the data in a way to confirm and investigate the root causes that lead to the event.

Having identified an event it needs to be explained or classified. The objective of the root cause investigation step hence is, to guide the user to the most likely explanation of the event. In cases of ambiguity further evidences can be requested by the system from the user, such as performing a visual analysis, running analytical or numerical tests or providing additional information. The final output of the problem classifier is a probabilistic estimation of what has most likely caused the event.

To set up a problem classification advisory system, the expert system can either be trained

using historical event data or, where no sufficient historical data is available, the network structures and according probabilities can be determined by experts (De la Vega et al., 2010).

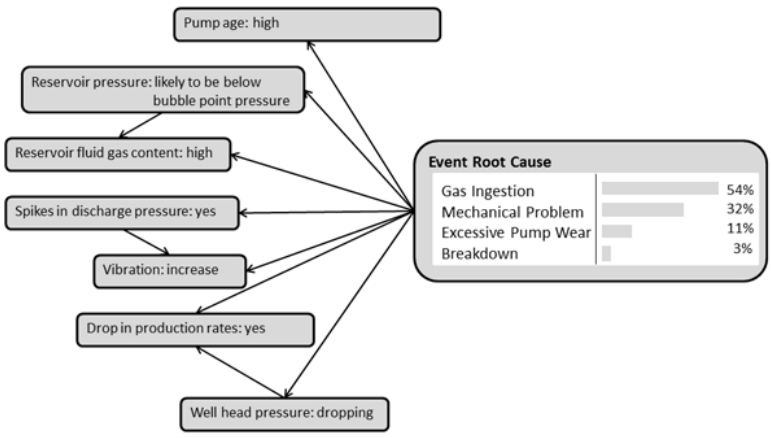
An example for a root cause identification using Bayesian Network is displayed in Figure 6. The most likely root cause for declining pump performance is determined based on the Bayesian Network taking into account the observations and real time measurements. The observations can be independent (e.g. pump age and reservoir pressure) but can also be linked by a causal relationship (e.g. well head pressure and production rates). The example shows that given the information about the pump, the reservoir, the fluid and measuring dropping liquid rates and wellhead pressures the most likely cause is gas ingestion, however, not entirely excluding mechanical problems and possible excessive pump wear (e.g. due to sand in the pump).

The Bayesian Network in this particular example is used as an explanation tool, supporting the asset team in limiting the likely causes from e.g. five possible problems to three reasonably causes given the data and prior information, hence reducing the 'search space' for the manual investigation to a small set of reasonably possible root causes.

The potential for automation in this step is actually also very high, however, it is the conviction of the authors that while some tasks may as well be automated (e.g. running a simulator (Barber et al., 2007), performing sensitivity analysis, etc.), the analysis and interpretation part should still be done by the user. The tasks should not be fully automated, but the user should be supported and guided by the system, through a guided workflow. Miligan, Deutekom and Buchan's (2008) definition of a guided workflow is that it "steers and guides users through a process or workflow and its activities, tasks and branches", which enables the organization to maintain the consistency and auditability of the work in their organization, while fully acknowledging the individual approaches and analysis preferences of their engineers.

The initiator for the guided workflows can either be the user, if the system recommendations, or identified problems seem unrealistic, or by the system, if it encounters unclear conditions, such as missing information, completely new situations, errors related to the networks algorithms, ambiguity in its results, etc. In this case the user can investigate all steps that led to

Figure 6. Bayesian network for well problem analysis, modeled



the events, problems or actions in detail and try to adjust, update or correct the system to find a suitable solution.

In case the advisory system cannot offer a distinct satisfactory solution, e.g. several problems with a very similar likelihood, similar utilities for recommendations, human interaction is requested. Probabilities, priorities and weights of intermediate utilities can be adapted by the user or expert to identify clear recommendations. Capturing the decision maker's reasons for or against various alternatives is an important step for the further improvement of the advisory system.

Decision Support System

So far the expert system has only been described in the context of detecting events or determining most likely reasons for these events. The expert system, however, can be extended to be a decision support system by adding objectives and utilities. A Bayesian Network for decision making in oil and gas operations needs to be extended by adding utility nodes and decision nodes. This allows to deploy Bayesian Networks in an even greater variety of tasks, including the computation of the expected utility, given uncertain observations and decision choices. For each problem identified in the root cause analysis, the best action over all available alternatives can be chosen. The best alternative is the one that meets the objective in the best possible way, hence maximizes the overall utility.

In most complex real world problems, decision criteria are conflicting in nature and their interrelations are often interdependent in complex and uncertain ways. Moreover, additional external factors, like the oil price or costs of services, play an important role and have to be included. The objectives and the weighting of different criteria in oil and gas operations strongly vary among companies.

The objectives for oil and gas operations may be summarized in 4 categories:

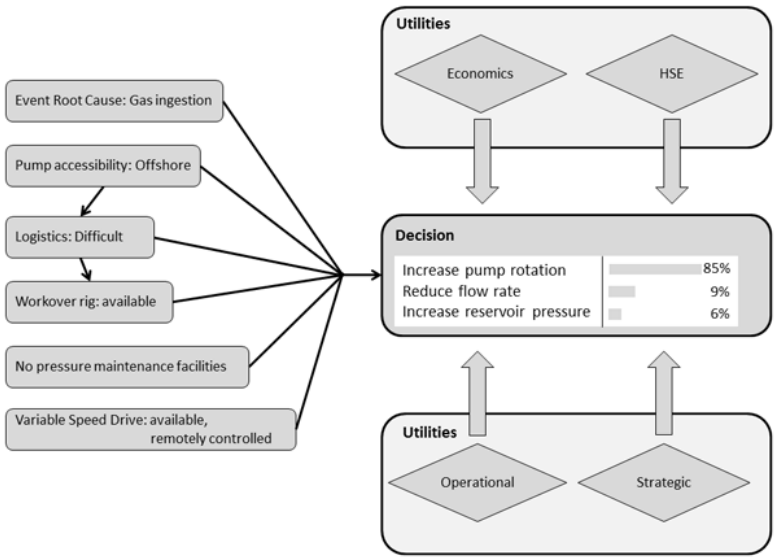
1. **Economic Targets:** The economic target can be assessed with the calculation of the net present value. This compares capital and operational expenditures with additional revenues generated (oil price, production rate) under temporal aspects (discount rate).
2. **Health, Safety, Environment (HSE) and Risk:** This category includes the probabilities of person injuries or fatalities, facility damages and environmental hazards. Typically HSE is a key aspect for oil and gas operations and hence decisions are favored that impose a low risk to HSE. This may lead to the fact that a decision is preferred even though it is technically not very effective, because it bears a significantly lower risk for the HSE factors.
3. **Operational Target:** Operational targets are short-term to medium-term targets and address efficiencies of processes (e.g. reduction of production downtime) or logistics (e.g. high utilization of equipment).
4. **Strategic Target:** Strategic targets mirror the company's preferences and long-term targets. An example for a strategic target may be a company's plan to increase its overall production rate. In this case additional production would be weighted more than costs to reach this goal.

The overall utility value is a combination of various sub-utilities, therefore a unified evaluating system has to be established for every organization or even for every project, that allows a comparison of monetary and non-monetary targets (see Figure 7).

The Feedback Loop

The decision taken by the asset team is based on their definition of utility and as such reflecting the asset team's prioritization. Actions that are taken by the asset team to counteract any encountered problems have the objective to either reduce risk

Figure 7. Expert system used in combination with utilities to find the most viable action in order to counteract an identified gas ingestion problem in an ESP. 'Increase pump rotation' has been used as most viable option with respect to the definition of utilities.



or increase the benefit in any of the sub-utilities as described before. Whenever a problem has been identified and an activity has been recommended by the decision support system, the system as well as the user creates an expectation of how the asset should react within a certain lag time (e.g. increase production, reduce production losses, etc.). This expectation is based on model computations, statistical analysis of past events or experience of the user. Setting the expectation is a key step in any decision making process as it defines the benchmark relative to which the success of the decision is to be measured.

Having a ticket system in place enables the asset team to track all activities around an event. The ticket will not be closed after the decision is taken, but after the success of the decision can be measured. The success in this context is defined as the conformance of the expectation of performance after the taken action and the resulting actual measurements. If the measurements are very close to what has been expected the success with regard to the advisory system is high and the system is hence assured of the recommended action, while a divergence between expectation and actual measurement imposes a learning opportunity that needs to be acknowledged by the advisory system. The probabilities and logic in the expert system needs to be adapted in order to reflect that a certain decision did not bring the expected added value.

With regards to the expert system based on Bayesian Networks, learning concerns the structure of the network and conditional probabilities. The primary application of Bayesian Networks is parameter learning or belief updating (Jensen & Nielsen, 2001). Setting up a Bayesian Network, we start with the expert knowledge (prior knowledge) about the model topology (causal relationship of the variables such as reservoir fluid gas content and gas ingestion) and the probability distributions of the nodes (see Figure 4). Where the Bayesian Network has led to decisions that did not result in the expected behavior, the beliefs in the net-

work (the probability distributions) need to be adjusted. In future encounters of the same events and problems the Bayesian Network will hence slightly modify its decision, taking into account the previous experiences.

The feedback step is typically not rigorously implemented in most of the teams and case studies known to the authors. Most of the time activities are not monitored throughout a longer time for a posterior evaluation and quantification of success. This leads to a very unfortunate loss of information as a learning system requires that the system understands, whether an activity was good or not.

The evaluation is an important step to sustainably improve the system and learn from bad as well as good experiences. For each ticket (problem) an evaluation is requested by the system. The time frame for an evaluation changes according to the problem or action. At the evaluation, the users are informed and provided with details on performance indicators, calculations, etc. They compare expected and actual outcome in a guided workflow and determine the reasons for diverging expectations and measurements.

The advisor captures all interactions of users, experts or the management and automatically adapts the probabilities of the nodes in the Bayesian Network. With each set of events or problems, the advisor can increase its knowledge space; each data input, decision or action further increases the accuracy of recommendations, it learns with every interaction. The system hence significantly benefits from a large number of users and from constant interaction with the system.

COLLABORATIVE ENVIRONMENT

The concept of an adaptive advisory system has been depicted and can now be used to infer its impact on the collaborative environment which has been divided into people, processes, technologies and organization. Each of them has its own requirements and challenges which have to be addressed and value must be generated for all participants to make the advisory system work. In general the authors anticipate the following challenges in the implementation of automated adaptive advisory systems in oil and gas operations.

People

The system is designed to replace the repetitive and error prone work of the asset team (e.g. data shifting, data preparation, etc.) and to complement the petrotechnical experts in the analysis and optimization work. It learns from input received from various groups and experts and could neither exist nor evolve without human interaction. The engineer has to learn and improve his own understanding too. This is especially important because it is the engineer who has to subject the identified problem to further analysis, set expectations regarding the outcome of a decision and to analyze the impacts of the decision made in the feedback loop.

It is also crucial not to deliver an out-of-the-box solution to the user by the advisory system but to put the engineer into a position to contribute and truly understand the problem and its solution. The adaptive system will ensure to a certain extent that engineers can contribute and take the ownership of the processes. This is necessary to increase the acceptance of the solution and the advisory system in general. Combined with an easy to use technology framework end users can be equipped with all tools necessary to develop their own knowledge workflows.

An obstacle in the acceptance of such as system may be a reluctance to participate in a fully transparent system due to a fear of exposure of personal failure. It is therefore extremely important to fully commit to a no blame culture and to establish an environment, where strong competition does not hinder exchange of lessons learned, knowledge and ideas. It will take a while until the

system has been calibrated well enough to gain the trust of the experts in an asset team. However, in contrast to other systems the here described advisor operates fully transparent and all steps, results and recommendations are fully traceable, which may reduce the time to acceptance within an organization.

It is further recommended that the user is involved in the design and setting of the advisory system, as he is the one who has to work with it. Regarding the option to adjust the settings in the decision supporter the petroleum engineer should have a wide insight into the decision structure to be able to understand their reasoning. Regarding the data layer, a data dictionary can support the asset team in selecting the needed data. It adds a level of abstraction and presents the tags of the database with their common engineering names to support the communication between the various engineering groups and the IT department in charge of the databases.

Nevertheless it might not be possible to precisely express which data is needed and its form from the very beginning. Changes in the data requirements may occur later on in the process and the system therefore needs to be prepared to accommodate these changes. The application of a domain specific framework that gives the end user - the asset team - the power of creating, modifying and controlling the processes is hence emphasized by the authors.

A top-down view on how the field and sensor measurements are utilized is promoted by the authors. Very often engineers focus too much on which sensor data are available and which methods can subsequently be applied and therefore forget about solving the actual performance constraint in the asset. We prefer the notion that the focus of an asset team should be on the challenge to overcome or at least manage a constraint. The activities to meet the challenges dictate the data and measurements that are needed. The changing conditions in the reservoir with time require different approaches and therefore impose the use of different performance indicators, which in turn are based on different data. The asset team needs to be able to react on these changing conditions without going through lengthy administrative data requests, which is why the technology framework in the hands of the end users will be of major benefit for an organization.

Skarholt, Næsje, Hepsø and Bye (2009) describe how the use of integrated operations has led to the development of peripheral awareness. This means that the asset team has developed a deep understanding of what is going on in the asset. The condition of peripheral awareness improves the organization's capability to achieve rapid responses, which in turn allows for more effective problem-solving and decision-making processes (Skarholt et al., 2009).

Process

The advisory system shifts the focus of the work in an asset from data preparation and data handling to production analysis and optimization. This imposes changes in the way asset teams perform their work. For example, data cleansing and quality control are critical factors in knowledge intensive workflows and automated workflows as the one described in this chapter. Since a big part of the workload for a user in manual process is in data provision and data preparation, the manual process ensures that the user has enough opportunities to get familiar with the data and potentially also to identify erroneous data. In a system, where repetitive tasks such as copy and pasting of data are automated to enable the petrotechnical staff to focus on value adding activities, it is critical to guarantee that the data are of highest possible quality while assuring that the users are still familiar with data. The quality of the decision support and subsequently the acceptance of the whole system essentially depend on the correctness in the identification of events and the reasons for asset performance problems, which in turn is directly related to the quality and reliability of the data.

Besides the issues around data quality it has to be pointed out, that users of the system are requested to document their activities rigorously and in a standardized format. This enables the system to file the information about all activities so that they can be reused or presented in context in future times. A strict documentation discipline will hence play an important role in the success of an advisory system like the one described in this chapter. Organizations will have to arrange for incentives to animate all users to share their findings, to contribute with their knowledge and essentially to improve and evolve the system.

The main sources of errors in this decision support system are a wrong identification of problem root causes or a wrong definition of utilities. In order to avoid any of those two errors it is important to install all necessary validation measures, which involve proper peer reviews, expert reviews and management reviews. *Lucky shots* are decisions which are made under false assumptions but for all that lead to an expected outcome. Those decisions will hence be validated positive. Lucky shots can alter the decision making system in an unfavorable way and at the worst overrule the expert system. A great challenge is hence the selection and setting of key performance indicators which measure the impact of a decision.

Technology

Currently the authors see the challenges of the implementation of a knowledge capturing and sharing system not so much in the technology, as all pieces that are necessary for a system like the one described in this chapter are readily available and well published, but in organizational aspects and change management challenges. The workflow engine is ready, databases are available and work with good enough performance to allow for prompt interaction, collaboration systems are available, the bandwidth for data transfers is sufficiently large and performs well, even over large distances, calculation engines can process can process huge amounts of data. Nevertheless each piece of the advisory system bears its own specific challenges. The authors see the biggest challenge in the definition of a comprehensive and reliable ontology of production operations and reservoir management problems. In contrast to other disciplines it is not straight forward to define an ontology covering all possible reservoir management issues as there is also no centrally accepted authority to issue general rules and guidelines in the management of a petroleum reservoir. It is therefore recommended by the authors to start with a subset of challenges, starting with the most frequent challenges that have the largest impact on daily operations and let system evolve as new information comes in and as new challenges need to be tackled.

Based on the identification of customization as one of the major challenges it is of major interest to develop the advisory systems based on a reusable and easily modifiable framework so that experts can add, modify or even remove components from the advisory system as new findings come in, new challenges show up or new expert opinions are elaborated.

Organization and Governance

It is the organization's task to monitor if data which is acquired, generated, stored and processed generates a value at the end. The different organizational units have to communicate among each other as well as with the end users, to ensure that. Otherwise huge amount of data will accumulate needlessly. What is more, the organization has to ensure the maintenance of data measurement devices such as sensors, in order to provide accurate data.

The advisory system improves with the number of users and events from which it learns. Therefore it is an attractive option to share the advisory system with other organizations within a company or even with outside organizations. However, this will bring up several other chal-

lenges. For example, although data itself has no value without the necessary understanding and data can be made anonymous for interpretation purposes, especially for national oil companies the data security and governance issue is very sensitive. While national oil companies might approach the concept of a shared knowledge base reluctantly, smaller companies have a greater incentive to share their knowledge with other parties because they have a greater benefit from an expert system. Nevertheless even national oil companies may not have the resources to keep all kind of experts in-house and may benefit from knowledge capturing and exchange.

The introduction of the concept of evidence based decision making (as used in medical sciences) into the advisory system has not been considered yet but is seen to be of considerable value as it will clarify issues around the validation of new findings. Some key issues still need to be resolved, e.g. the definition of technical levels of information sources (e.g. junior engineer, senior engineer, expert, case study, simulation study), the creation of rules for compulsive decision making (e.g. expert recommendation overrules junior engineer recommendation) and the introduction and rigorous acknowledgement of these evidence levels in the advisory system (problem identifier, decision support).

Capturing of knowledge and best practices is in the interest of organizations as companies are losing their skilled engineers due to the big crew change. Thought has to be given to the fact that knowledge is an engineer's main asset. To get people to collaborate and share their knowledge a system of incentives has to be designed which addresses different types of engineers. Especially for younger engineers which are used to an environment where information is shared constantly, a major incentive could be achieving a good reputation within a community. Nevertheless it is inevitable that their collaboration has to be coupled with career leverage.

The change management aspect needs to be considered properly in order for an advisory system implementation to be an organizational success. Workflows and processes that support the use of an advisory system need to be in place. In contrast to conventional operations workflows are not isolated anymore and highly benefit from intense collaboration and networking among the different disciplines, assets and functions.

SUMMARY

The chapter presented how an automated expert system can be used to integrate information from various sources under a common decision support system that honors the logic and understanding of exerts from various disciplines. The consistent and prompt screening will not only reduce decision making time but also improve decision quality in a petroleum asset team as information and previous experiences are documented and presented in context to help the asset team during ongoing operations.

The authors are convinced that workflow standardization in reservoir management needs to consider the changing conditions in the field and needs to be able to learn as operations continue. Knowledge and experience in the oil and gas industry are not as standardized as in other sciences, because production behavior and challenges vary from reservoir to reservoir. This is the reason why expert systems need to be tailored to every reservoir. The adaptive advisory system may hence be a very suitable approach as the system eventually will be customized enough to very efficiently support the asset team in their daily operations.

Although the technology and tools for decision support systems are already in place since decades, they are not as widely implemented as one would expect. Considering this fact it becomes clear that the question of implementing a decision support system is not just a technical one. The is-

sues concerning people, process, organization and governance turn out to be highly challenging when it comes to the implementation and ultimately to the success of a system like that.

The advisory system and the framework will provide the tools to give the ownerships of production and reservoir management workflows into the hands of the main users, the petrotechnical experts in the fields and the assets. In the authors opinion this is a critical factor in order to enable efficient knowledge sharing and to maintain sustainable reservoir management and production optimization workflows in an asset. Ultimately the goal is to build a growing knowledge base in an organization that reduces lost production significantly and maintains the expertise with the organization and within the industry.

REFERENCES

Barber, A., Shippen, M., Barua, S., Velázquez, J., Hernández, A., & Klumpen, H. (2007). Optimizing production from reservoir to process plant. *Schlumberger Oilfield Review*, *19*(4), 18–29.

Behounek, M. (2003). Five elements for successful knowledge management. *Journal of Canadian Petroleum Technology*, April, 12-14.

Bellinger, G., Castro, D., & Mills, A. (2004). Data, information, knowledge, and wisdom. *Systems Thinking*. Retrieved December 16, 2011 from http://www.systems-thinking.org/dikw/dikw.htm

Bloedorn, E., & Wnek, I. (1995). Constructive induction-based learning agents: An architecture and preliminary experiments. *First International Workshop on Intelligent Adaptive Systems* (pp. 38-51). Melbourne Beach, Florida, US.

Brulé, M., Charalambous, Y., Crawford, M., & Crawley, C. (2008, September). *Bridging the gap between real-time optimization and information-based technologies*. Denver, CO: SPE Annual Technical Conference and Exhibition.

Buchanan, B. G., & Shortliffe, E. H. (1984). *Rule-based expert systems: The MYCIN experiments of the Stanford heuristic programming project*. Reading, MA: Addison-Wesley Publishing Company.

De la Vega, E., Sandoval, G., Garcia, M., Nunez, G., Al-Kinani, A., & Holy, R. W. … Mota, M. (2010, March). *Integrating data mining and expert knowledge for an artificial lift advisory system*. Utrecht, The Netherlands: SPE Intelligent Energy Conference and Exhibition.

Hatch, D. (2009). *Operational business intelligence: Five things you need to know about improving your costumer-facing performance*. Aberdeen Group. Retrieved August 10, 2011, from https://www1.vtrenz.net/imarkownerfiles/ownerassets/1076/5392-RA-Operational_BI-DH-04-NSP1.PDF

Hite, J. R., Crawley, C., Deaton, D. F., Farid, K., & Sternevsky, M. (2007, November). *Barriers to implementation of real-time optimization technology.* Anaheim, CA: SPE Annual Technical Conference and Exhibition.

Jensen, F. V., & Nielsen, T. D. (2001). *Probabilistic decision graphs for optimization under uncertainty*. New York, NY: Springer-Verlag.

Kerman, M. C., Jiang, W., Blumberg, A. F., & Buttrey, S. E. (2009). Event detection challenges, methods, and applications in natural and artificial systems. *14th International Command and Control Research and Technology Symposium (ICCRTS)* (p. 58). Washington, DC: Lockheed Martin.

Miligan, G., Deutekom, M., & Buchan, C. (2008, February). *Guided workflow for the digital oil field: A practical example*. Amsterdam, The Netherlands: SPE Intelligent Energy Conference and Exhibition.

Miller, K. I., & Monge, P. R. (1986). Participation, satisfaction, and productivity: A meta-analytic review. *Academy of Management Journal*, *29*(4), 727–753. doi:10.2307/255942

Mitchell, T. (1997). *Machine learning*. Singapore: McGraw-Hill.

Newell, A., & Simon, H. (1972). *Human problem solving*. New Jersey: Prentice Hall.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York, NY: Oxford University Press.

Rostand, A., & Soupa, O. (2011). Benchmark survey reveals looming talent shortage. *E&P Magazine*. Retrieved August 15, 2011, from http://www.epmag.com/Magazine/2011/5/item81982.php

Sagli, J. R., Klumpen, H. E., Nunez, G., & Nielsen, F. (2007, November). *Improved production and process optimization through people, technology, and process*. Anaheim, CA: SPE Annual Technical Conference and Exhibition.

Sartika, Y., & Suwardi, I. (2007). Generic expert system – Incremental learning system. *International Conference on Electrical Engineering and Informatics* (pp. 564-566). Bandung, Indonesia: Institut Teknologi Bandung.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. S. (2009). Integrated operations and leadership - How virtual cooperation influences leadership practice. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications* (pp. 821–828). London, UK: CRC Press, Taylor & Francis Group.

Stundner, M., Nunez, G., & Møller Nielsen, F. (2008, February). *From data monitoring to performance monitoring*. Amsterdam, The Netherlands: SPE Intelligent Energy Conference and Exhibition.

Van Gerven, M. (2007, September). *Bayesian networks for clinical decision support: A rational approach to dynamic decision-making under uncertainty*. SIKS Dissertation Series. Retrieved November 20, 2011, from http://dare.ubn.kun.nl/bitstream/2066/30201/1/30201_bayenefoc.pdf

Woolf, P. (2009). Bayesian networks I - Static models and multinomial distributions. *Chemical Process Dynamics and Control*. Retrieved November 20, 2011, from https://controls.engin.umich.edu/wiki/images/d/da/Lecture.26.pdf

Zangl, G., Al-Kinani, A., & Stundner, M. (2011). *Holistic workflow for autonomous history matching using intelligent agents: A conceptual approach.* SPE Digital Energy Conference and Exhibition.

Zangl, G., & Hannerer, J. (2003). *Data mining applications in the petroleum industry*. Katy, TX: Round Oak Publishing.

ADDITIONAL READING

Al-Kinani, A., Nunez, G., Stundner, M., Zangl, G., Iskandar, O., Mata, T., et al. (2009, May). *Selection of infill drilling locations using customized type curves*. Cartagena de Indias, Colombia: SPE Latin American and Caribbean Petroleum Engineering Conference. SPE-122186-MS, doi: 10.2118/122186-MS

Baumgartner, N., Gottesheim, W., Mitsch, S., Retschitzegger, W., & Schwinger, W. (2009) On optimization of predictions in ontology-driven situation awareness. *Proceeding of the 3rd International Conference on Knowledge Science, Engineering and Management*. Berlin, Germany: Springer Verlag. doi: 10.1007/978-3-642-10488-6

Brown, K., Chandler, K., Hopper, J., Thronson, L., Hawkins, J., & Manai, T. (2008). Intelligent well technology in underground gas storage. *Schlumberger Oilfield Review*, *20*(1), 4–17.

Clemen, R. (1996). *Making hard decisions: An introduction to decision analysis* (2nd ed.). Pacific Groove, CA: Duxbury Press.

De la Higuera, C. (2010). *Grammatical inference: Learning automata and grammars*. Cambridge University Press.

Du Castel, B. (2011). Human-centered oilfield automation. *Schlumberger Journal of Modeling, Design, and Simulation, 2*.

Flinn, S. (2010). *The learning layer: Building the next level of intellect in your organization*. New York, NY: Palgrave Macmillan.

Giese, G., & Bratvold, R. B. (2010). *Probabilistic modeling for decision support in integrated operations*. Utrecht, The Netherlands: SPE Intellingent Engergy Conference and Exhibition.

Graf, T., Zangl, G., May, R., Hartlieb, M., Randle, J., & Al-Kinani, A. (2011). Candidate selection using stochastic reasoning driven by surrogate reservoir models. *SPE Reservoir Evaluation and Engineering, 14*(4), 413-422. SPE-136373-PA. doi: 10.2118/136373-PA

Hollifield, B., & Habibi, E. (2007). *Alarm management: Seven effective methods for optimum performance*. Research Triangle Park, NC: ISA – Instrumentation, Systems and Automation Society.

Jensen, F. (1997). *Bayesian Networks and Decision Graphs*. New York: Springer.

Mayrhofer, R., Radi, H., & Ferscha, A. (2004). Recognizing and predicting context by learning from user behavior. *Radiomatics: Journal of Communication Engineering. Special Issue on Advances in Mobile Multimedia*, *1*, 30–42.

Neapolitan, R. (2003). *Learning Bayesian networks*. Upper Saddle River, NJ: Prentice-Hall.

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Chapter 17
Integrated Operations from a Change Management Perspective

Tom Rosendahl
BI Norwegian Business School, Norway

Asbjørn Egir
Astra North, Norway

Lars Kristian Due-Sørensen
BI Norwegian Business School, Norway

Hans Jørgen Ulsund
Vitari, Norway

ABSTRACT

The purpose of this study is to investigate the factors that have been prominent in driving or restraining the implementation of Integrated Operations (IO) within the Norwegian oil industry - from a change management perspective. The authors focus on trends in implementing Integrated Operations across companies on the Norwegian Continental Shelf. The research is a cross-sectional case study, based on interviews with 15 respondents and the use of relevant documents. Findings are presented in a modified version of Lewin's Force Field Analysis. The authors have found multiple forces that have affected the implementation of Integrated Operations to various extents. This chapter focuses on three of them: Understanding the rationale of IO; Establishing support for change; and Technological solutions. Findings based on data gathered across multiple organizations in the Norwegian oil industry should yield a great potential for improving the future development and implementation of Integrated Operations.

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INTRODUCTION

Since oil first was found and extracted on the Norwegian Continental Shelf (NCS) in the early 1970s, this industry has served as the main contributor to the rise of Norwegian economy and welfare. Numbers presented by Statistics Norway in 2009 stated that 47 000 persons were employed in the Norwegian oil and gas industry. In addition, in 2010 the industry was attributed 22% of Norway's total GDP, demonstrating its central position in the Norwegian economy.

As with companies in any other industry, the operators on the NCS compete for profits and competitive advantage. By the turn of the millennium, a new way of organising work that is heavily based on utilisation of new technology was introduced in the industry. By taking advantage of real-time data, multidisciplinary teams and increased decision accuracy, Integrated Operations (IO) has been expected to enhance the effectiveness and efficiency of work processes in the sector (OLF 2007). However, since this is a new way of organising work, there is a certain risk that issues will arise in relation to the implementation.

The purpose of our study was to investigate how IO and its work processes have been implemented within organisations operating on the NCS. Different IO-related initiatives have been introduced in the industry over the past ten years, and, as a consequence, we wish to assess the implementation during this period of time. To do so, we want to map out the different driving and restraining forces effecting change. We will look into the major IO initiatives that have been undertaken within the industry, what the intended effects have been, and to what extent the overall implementation has been successful. As an analyzing tool, we have utilised a modified version of Kurt Lewin's Force field analysis (Buchanan & Huczynski 2010; Burns 2009; Cummings & Worley 2009; Green 2007). By combining this tool with the central aspects of IO implementation, we want to get an overview of how change has been managed. Further, by mapping out these forces, we will attempt to gain a deeper understanding of how IO-related initiatives have been implemented with regards to employee commitment and potential resistance to change, since these concepts have been shown to have a significant influence on the outcome of change (Buchanan & Huczynski 2010; Ford, Ford & D'Amelio 2008; Beer & Nohira 2000; Piderit 2000).

The oil industry's great significance for the Norwegian economy underlines the need for a study that assesses potential success criteria for the IO implementation. Our research evaluates the implementation across company boundaries, and we hope that our findings will yield some value for the Norwegian oil industry as a whole. In a more general perspective, we also hope that this study can be of some contribution to the large base of change management literature since it involves research on employee commitment and resistance to change.

CHANGE MANAGEMENT THEORY

In a constantly evolving world, the need for organisations to anticipate change and reconfigure themselves is more important than ever (Lawler & Worley 2009). Buchanan & Huczynski (2010) propose that the evolving cycle of repeated change can be explained by three basic factors. First is the intense competition and stock market turbulence in the private sector along with consumerism and government pressure in the public sector. Second, the pace of technological innovations plays a major part, and third, increased knowledge-intensity, as organisation design affects information flows. Beer and Nohria (2000) estimate that about two-thirds of change projects fail, a fact that is supported by Whittington and Mayer's (2002) research claiming that outcomes of major organisational change often are disappointing. Evidently, to achieve successful change in an organisation, there will be a fundamental need

to devote sufficient attention to the management of change. We will, in the following, go through what we consider to be some of the most important literature in regards to the implementation of IO within organisations operating on the NCS.

Commitment to Change

One of the most essential aspects related to successful change is the establishment of employee commitment (Buchanan & Huczynski 2010; Cummings & Worley 2009; Beer & Nohira 2000). Commitment is often described as an employee's attachment to an organisation, but this association might also have other referents such as an organisational subunit, a supervisor, or even a particular program or event, for example, a change occurring within the organisation (Herscovitch & Meyer 2002). For example, Fedor, Caldwell & Herold (2006) found evidence to suggest that the favorableness of an organisational change is positively related to perceptions of both change and organisational commitment. In other words it might be useful to distinguish between commitment towards the organisation as a whole, and the change process itself.

Establishing commitment towards the change process is imperative for an organisation to harness the expected benefits of a change initiative. Such commitment can, in many ways, be defined as the willingness to exert effort on behalf of the change (Fedor, Caldwell, & Herold 2006). In addition, it is vital to separate commitment to change from mere compliance, since the long term benefits occur when employees actively work to support the change and maintain or enhance their alignment with the organisation's values and goals (Fedor, Caldwell & Herold 2006; Beer & Nohira 2000). Thus, when employees act on compliance and simply do as they are commanded, there will be a lack of motivation over time that might impair the effects of change. Employee commitment is an important aspect for organisations to take into account in order to manage change effectively. But how is such commitment established? In the following we will review some theoretical concepts that are central in ensuring dedication and effort towards the implementation of change initiatives.

Employee Involvement

According to Cummings & Worley (2009), employee involvement generally seeks to "increase members' input into decisions that affect organisation performance and employee well-being" (p.351). In a change-related context, Buchanan & Huczynski (2010) suggest that those who are being affected by the change should be involved in the planning and implementation of new initiatives to reduce opposition and ignite commitment. To gain and maintain such involvement is a continuous process that stretches over the lifetime of the change project. Beer, Eisenstat & Spector (1990) underline that even though members of top management often understand that there is a need for establishing employee commitment and involvement, they seldom realise that changing employee behavior takes more than introducing new formal structures and systems in the organisation. In their study, they found that the greatest obstacle of organisational revitalisation is that it comes about through companywide change programs. To achieve successful change, they claim that initiatives must develop from lower levels of the organisation through the active involvement of employees focusing on how to solve actual work-related problems (Beer, Eisenstat & Spector 1990).

This quest for achieving successful change through employee involvement can be traced back to a more fundamental issue within change management theory. Should change be implemented from the top-down, or should it evolve from the bottom and up? In Beer & Nohria's book "Breaking the Code of Change" (2000), these two seemingly contrasting perspectives are discussed. Conger (2000) speaks for a top-down approach

to change, since senior managers are in the best position to plan and coordinate organisational change. After all, top management possesses the advantage of having breadth of perspective of the organisation. However, Bennis (2000) claims that successful change only can occur by having willing and committed employees. Since top management has a limited ability for understanding the complexity of operational tasks in the different units, organisational change is not possible without the inclusion, initiative, and cooperation of the employees. Beer & Nohria (2000) conclude that both approaches must be taken into account to achieve change successfully. Employee involvement and participation are required both to assist in the planning of change, as well as in the execution (Beer & Nohria 2000; Dunphy 2000).

RESISTANCE TO CHANGE

The human side of implementing the different aspects of IO can be a major challenge, since it affects the work situation of many of the employees in the organisation. When confronted with a change, humans normally react in one of three possible ways regarding how to comprehend the change: by acceptance, by ambiguity or by resistance (Ford, Ford & D'Amelio 2008). Therefore, when a company is going through changes, it must be aware of the fact that some employees might resist the change. In fact, employee resistance has been cited as the main factor that derails change initiatives (Regar et al. 1994; Kotter 1995). Kurt Lewin defines resistance to change as "a restraining force moving in the direction of status quo" (Piderit 2000, p.784) and it might be conceptualised as a cognitive state, an emotional state or as a behavior. We believe this might be an area that could potentially cause the implementation of IO to be slower and more difficult than first proposed by the OLF, and as a consequence, an important restraining force to change.

Reasons for Resistance

Since resistance to change can have such a detrimental effect, we will try to shed some light on what can be the source of this resistance. Because the concept is complex, it can be observed in various ways. Yukl (2010) describes some important, not mutually exclusive, reasons for resistance, and we will include four of these that we perceive to be most applicable for the case in the Norwegian oil industry:

1. Belief that change is unnecessary. If the organisation has been successful, and there is no visible trouble on the horizon, resistance is more likely to occur when change is introduced. Even when a problem is recognised, people usually confront it by trying to adjust previous strategies or to do more of the existing routines, instead of changing. The belief that change is unnecessary might be an issue in an industry – like the oil and gas industry – where profits are high and business is generally going well (SSB.no).
2. Economic threats. Employees might fear that they will suffer personal loss of income, benefits and job security as a consequence of organisational change. Thus, economic threats might increase resistance, especially in situations where employees have painful experiences of downsizing and layoffs in the past. As IO brings about rationalisation within the organisations, leading to a reduced need for off-shore staff, this source of resistance might be particularly relevant in our case.
3. Loss of status and power. Since changes often imply a shift in power and status for some teams or individuals, employees holding positions that most likely will be affected negatively might be more prone to oppose the change. In relation to IO, experts working in multidisciplinary teams might experience an increase in status and power, while those

who stay put in their ordinary positions might experience a similar decrease.

4. Resentment of interference. Some employees simply do not like to feel controlled by others, and attempts in changing their job situation are likely to cause resistance. IO will for some involve severe changes in their everyday work processes, and this might provoke a feeling of being restricted.

Overcoming Resistance to Change

Cummings and Worley (2009) describe three major strategies for dealing with resistance to change. First is the notion of empathy and support. By being able to see the situation from another perspective and thus learn why people are resisting the change, it is possible to convince employees of the usefulness of the change. Second, it is very important to have a high focus on effective communication, and always keep the employees informed about forthcoming changes and the likely result. Because of the vast amount of information already coming through existing channels, it is vital that the information regarding change is delivered through new or different channels than previous information. The third, and maybe the strongest strategy, is using participation and involvement of the employees in the planning and implementation of change. This increases the likelihood that the employees interests and needs will be accounted for, which will help raise commitment, because doing so will suit their interest and meet their needs (Cummings and Worley 2009).

Resistance to Change: An Asset?

While resistance to change can have damaging effects on the outcome of change, some research is challenging the idea that resistance merely should be regarded as an obstacle that needs to be eliminated. Piderit (2000) suggests that researchers have ignored the potential positive intentions that may motivate negative responses to change, and that a strategy of fostering ambivalence and resistance in the early stages of a change initiative actually can be fruitful to see the change process from different angles. The problem is, however, that managers often perceive resistance as purely negative, and that employees who resist change are seen as disobedient (Piderit 2000).

Ford, Ford & D'Amelio (2008) are concerned with the same issue in their study on alternative ways of perceiving resistance to change. They point to the fact that resistance to organisational change seldom is presented as a product of rational, coherent objectives and strategies, even though resistance to persuasion has been found to come as a result of thoughtful consideration (Ford, Ford & D'Amelio 2008). In addition, resistance to change is almost never portrayed as a potential contributor to effective change, even though authentic dissent has been shown to be useful in other areas of management. Thus, the authors propose that resistance to change actually might be utilized as an asset for organisations going through change (Ford, Ford & D'Amelio 2008). Since what is referred to as resistance to change is very common, and perhaps even inevitable, there is a need for organisations to address this issue the right way. Knowles & Linn (2004) support the arguments above and propose that if an organisation can use resistance in a productive way, it might create value for the existence, engagement and strength of the change, and thus act as a resource instead of a restraint to change.

Now, how should organisations go about utilizing resistance as a resource for achieving successful change? First, Ford, Ford & D'Amelio (2008) propose that resistance might be utilised in keeping the conversation about change in existence, since it ignites debate and creates awareness. In this way, the idea of change will gradually root within the organisation. Second, resistance might be valuable in that it represents a possible form of engagement (Piderit 2000). Thus, in some cases, resistance

may reflect a higher level of commitment than mere acceptance will. Third, since resistance is a form of conflict, and conflicts have been shown to improve the quality of decisions (Ford, Ford & D'Amelio 2008), it is possible that resistance will improve the quality of change. By involving conflicting thoughts and ideas in the planning of change, different perspectives will shed light on which might bring about a better final outcome. Further, Piderit (2000) suggests that managers and change agents should utilise a new conceptualisation of employee ambivalence to change, focusing on at least three multidimensional attitudes (emotional, cognitive and intentional). This will break down the traditional, simplified perception of resistance, and provide for a better understanding of employees' feelings, thoughts and intentions towards change.

Kotter's 8-Stage Model of Change

According to Harvard Professor John P. Kotter (1996), the increasing global focus of many organisations creates a more competitive atmosphere for companies, and as a result, they have to increase productivity, reduce costs, improve the quality of products and services, and find new opportunities for growth. As a consequence, companies need to be able and ready to implement change. Historically, many companies have failed to do this in a satisfactory way, leading to wasted resources and tired and frustrated employees (Kotter 1996; Kotter & Cohen 2002). In order to avoid the potential pit-falls related to the implementation of change, Kotter describes an eight-stage process intended to enhance the likelihood of successfully managing major change. Step one to four help refreeze a hardened *status quo*, making the organisation ready to implement the proposed change. Stage five to seven are concerned with instigating new activities and routines. Kotter (1996) explains that a major problem for today's companies is that they only devote their full focus on these three stages. Stage eight is perhaps the most difficult to complete and is a stage that requires protracted attention. It ensures that the change sticks, and becomes the new way of doing things.

The eight steps are as follows (Kotter 1996):

- Establishing a sense of urgency
- Creating a guiding coalition
- Developing a vision and strategy
- Communicating the change vision
- Empowering broad based action
- Generating short-term wins
- Consolidating gains and producing more change
- Anchoring the new approaches in the organisational culture

It should be emphasized that even though Kotter's model is depicting change over time, the stages do not necessarily unfold in a linear sequence (Bolman & Deal 2003). According to Bolman & Deal (2003), much of its value lies in that the model incorporates different dimensions vital for successful change, namely structural, human, political as well as symbolic elements.

The Force Field Analysis

As brought up earlier, Kurt Lewin defined resistance to change as "a restraining force moving in the direction of *status quo*" (Piderit 2000, p.784). According to Lewin, the nature and pace of change are depending on the balance between the driving and restraining forces within a field. A field's progression is never static, Lewin claimed, but always in a continuous state of adaption (Burnes 2009). Therefore he used the term quasi-stationary equilibrium to indicate that "whilst there might be a rhythm and pattern to the behavior and processes of a group, these tended to fluctuate constantly owing to changes in the forces or circumstances that impinge on the group" (Burnes 2004, p.981). A technique for assessing the balance of the mentioned factors that push or hold back movement towards the desired target situation was developed

and named the Force field analysis (Buchanan & Huczynski 2010; Burns 2009; Cummings & Worley 2009; Green 2007). The rationale behind this tool is basically to identify all forces within a field (organisation or group) that will effect change to some extent.

As part of the analysis in this article, we will utilise a slightly modified version of the Force field analysis, where we - based on the empirical evidence gathered – will map out the most important factors that drive or restrain the implementation of IO within the Norwegian oil industry. In order to do so we will in the following make some clarifications about the assumptions on which this analytical tool is based.

Modifications

As Ford, Ford & D'Amelio (2008) do, we believe that resistance to change is a natural human reaction that does not necessarily impair the progression of planned change in an organisation. Rather, resistance should be seen as a phenomenon that refines the organisation's new way of doing things. Accordingly, it is necessary for us to make some modifications to Lewin's original Force field analysis. First, we would like to clarify that we do not expect forces to exclusively drive or restrain overall change. A force might be multidimensional in that it affects an organisation in different ways; it can, for example, drive change in terms of speed/time and at the same time restrain change in terms of lack in quality. Second, in order to make our analysis more comprehensible, we will divide the force field into three sub-dimensions based on the concept of Man-Technology-Organization (MTO) as presented by Andersson & Rollenhagen (2002). In this way, we will be able to consider the different aspects of change in relation to the driving and restraining forces. Third, Lewin originally developed this analysis for use in individual-, group- or organisational settings (Cummings & Worley 2009). In our research we will apply the tool when we investigate multiple organisations within the Norwegian oil industry.

METHODOLOGY

The purpose of our study is to investigate how IO and its work processes have been implemented within organisations operating on the NCS. As previously mentioned, the different IO-related initiatives have occurred gradually over the past ten years, and, as a consequence, we wish to assess the implementation during this period of time. To do so, we want to map out the different driving and restraining forces effecting change. We will look into the specific IO initiatives that have been undertaken within the industry, what their intended effects have been, and to what extent the implementation has been successful. The aim of this study is to answer the following research question:

How has Integrated Operations been implemented within the Norwegian oil industry, and what factors have been prominent in driving or restraining the implementation?

Further, by mapping out these forces we will attempt to gain a deeper understanding of how IO-related initiatives have been implemented with regard to employee commitment and potential resistance to change. To investigate the phenomena of IO implementation and change management, we will utilise a qualitative methodological approach, since it allows for assessing "the meanings, concepts, definitions, characteristics, metaphors, symbols and descriptions of things" (Berg 2009, p.3).

Research Design

To investigate our research question, we have conducted a case study and we have utilised what is referred to as a single-case design. This basically means that one single case is going to be used to address the research question (Yin 2009). In order to strengthen our findings, we have gathered data from multiple organisations operating on the NCS. This is referred to as a cross-sectional design (or embedded case study), implying that our focus is on a sample of events rather than on one individual

situation (Yin 2009; Bryman & Bell 2011). The fact that we have conducted our study in multiple organisations allows us to compare and contrast the findings across different organisations. This provides us with the opportunity to map out trends and consider those factors that are common for the entire industry (Berg 2009).

Sources of Evidence

Based on Yin (2009), we have prioritized three important sources of evidence - interviews, archival records and documentation to achieve what Bryman and Bell (2011) refer to as triangulation. It is important to bear in mind that these sources have their strengths and weaknesses, and they should be viewed as complementary. The goal of our interviews has been to extract a coherent explanation, while acknowledging that each of the participants might have their own way of understanding the phenomenon, and hence their own explanation (Rubin & Rubin 2005). To achieve quality and accuracy during our interviews, we utilised a semi-structured interview (Bryman and Bell 2011).

Sample

We have conducted our research in some of the largest companies operating within the Norwegian oil industry, namely Statoil, ConocoPhillips, BP, Shell and Halliburton. We have also interviewed people representing OLF, Petoro and different labor unions. In order to conduct our in-depth, expert interviews, we required contact with people who had extensive experience with IO and its implementation. It was important for us to gain insight into both the leader/change agent perspective, as well as the employee perceptions. Thus, we made sure that both viewpoints were taken into consideration when selecting respondents for our study. This has allowed us to gain a deeper insight of the different layers within each organisation. We felt that perceptions might differ between people in top management *versus* lower level employees.

Pilot: In-depth Interview

By performing a pilot test, we had an opportunity to refine the structure and content of our interview guide and, according to Bryman & Bell (2011), this helps ensure that the interview questions operate well and that the research instrument, as a whole, functions properly.

Use of Kotter

To capture different dimensions of the IO implementation, we choose to use Kotter's 8-stage model as assistance in structuring our interview questions. As previously mentioned, the model is widely recognized for explaining crucial aspects of large-scale change (Buchanan & Huczynski 2010; Burns 2009; Cummings & Worley 2009).

Scientific Value

We have taken particular care to establish the construct validity, external validity and reliability of our study. In relation to construct validity we have 1) used several sources of evidence, 2) structured the study based on a logical progression, and 3) had a key informant reviewing the case study report (Yin 2009). To ensure external validity in our study, we have attempted to interview experts from a wide selection of the most important operators within the industry. The rationale is that a broad and equal inclusion will allow our findings to say something about the industry as a whole (Yin 2009). As the respondent list indicates, one of the organisations, Statoil, has been devoted more attention since it is the responsible operator for about 60% of the total production on the Norwegian Continental Shelf (Henriquez 2008). To ensure the reliability of our study, we have kept close records of our own progression, documenting when, how and from whom data has been gathered. In addition, we have recorded and stored all of our interviews, and kept the data files so that we could go back at any time if something were to be unclear (Yin 2009).

ANALYSIS

The following analysis is based on about 50 000 words of transcribed interviews distributed among 15 respondents, as well as relevant documents gathered from within the industry. The analysis' structure is founded in the driving and restraining forces we have discovered in our force field analysis. In the following analysis, the different forces we have mapped out are recognised by italic letters. We will present three bulks of factors that we found most important. In addition to these we also found evidence to suggest the following relevant bulks of factors related to the implementation of IO: Experimentation and local creativity; Stakeholder involvement; Collaboration rooms; Training; and Communication.

Understanding the Rationale of Change

As described earlier in this paper, the Norwegian oil industry can in many ways be described as a lucrative and profitable industry (SSB.no). The implementation of IO-related initiatives has had the purpose of ensuring this profitability by increasing the effectiveness, production and safety in the industry (OLF 2008). Intuitively, we would assume that organisations operating on the NCS might face challenges in establishing an understanding for the implementation of new work processes – after all, the previous ways of performing work was apparently working well. So, has there been a particular need for establishing a sense for urgency and convincing employees to embrace IO? Our respondents unanimously reported that that the vast majority of employees in the different organisations understood the need for IO and accepted the rationale behind change. First of all we found that there seemed to be a common understanding of the purpose/rationale for change. The fact that IO-related work processes actually help make the involved people's working day less complicated has created a desire to take part in the development. Perceiving the implementation of IO as a "win-win" situation has seemed to motivate employees toward commitment and even enthusiasm.

Second, we found that organisations that were perceived by our respondents to be permeated by a "there is always room for improvement" –mentality experienced less employee resistance in the implementation of IO. When the organisational culture was characterised by a high degree of openness to change, new initiatives were met with less negativity and skepticism. This is what Holt et al. (2007) refer to as "readiness for organisational change" – where readiness arguably is considered one of the most important factors involved in the employees' initial support for change initiatives. Based on the data gathered in our interviews, we found an organisational culture embracing change to be an important driver for large scale implementation of IO within the Norwegian oil industry. This implementation can be defined as a continuous change process that has been evolving over the past 10 years (Beer & Nohria 2000). The initial visions for IO have been somewhat "hairy" since no organisations knew precisely where the development was headed. In retrospect, our respondents inform that the path has appeared as they have walked it, and to steer the development of IO after specific long term goals has been perceived as impractical. Thus, developing a vision for IO that made sure the organisation moved in one direction and allowed for gradual adjustments has been an important driver for implementing IO. A clear vision will also assist in establishing a shared understanding of purpose, as described in the section above.

Even though the implementation of IO as a whole can be seen as a continuous change process, it does consist of multiple cycles of episodic initiatives. We found that for each and every IO initiative there was a profound need for the development of specific, short-term goals. In our interviews, it was revealed that such specific goal setting had only been completed to a vary-

ing extent within the industry, depending on the organisation. While some had a huge emphasis on achieving specific ends with their initiatives, others applied a more loosely planned approach. It was, however, a shared understanding among our respondents that establishing tangible goals and having a thorough evaluation of the initiatives was of great importance. To evaluate the effect, there is a need to measure the effect of IO initiatives. Such measurement can be performed in relation to a vast array of parameters, the most usual being significant KPIs (Key Performance Indicators), operational uptime offshore, production volume, as well as financial results. In addition, IO has, to some extent, been used as part of the criteria in which leaders are being evaluated. The measurement of different initiatives can function as a driver for change as it documents the (potential) effectiveness of IO activities. Such results can be used in convincing various stakeholders of the value IO holds.

When short term goals have been reached and visualized, we found a coherent focus among our respondents on the driving effect of celebrating the short-term wins. Collecting the "low-hanging fruits" along the way has contributed to keeping the momentum up during the implementation, signaling to employees that the change is headed in the right direction, and increasing the likelihood for eventually reaching the overall vision.

Establishing Support for Change

Our respondents were pretty clear on the importance of establishing a guiding team or coalition. These teams could consist of leaders on different levels, hired professional change agents and coaches, experts in the areas involved and other key personnel deemed important to the change. The main responsibility of the team would be to guide and support the implementation process and make sure the changes were supported and carried out by employees. For the IO initiatives to be implemented successfully, comprehensive support from the senior management has been absolutely indispensable. By wholeheartedly showing its belief in change, providing the required resources and being active participants in the process, senior management can demonstrate the importance of the change initiatives (Burns 2009; Kotter & Cohen 2002; Kotter 1996). In this manner, employees might get the feeling of the actual worth and significance the organisation places on IO, and, as a consequence, being more inclined to committing to change.

Further, some of our respondents highlighted the importance of identifying individuals who strongly support or object to change, and then utilizing positive, key personnel in driving change. When employees were presented with co-workers who strongly supported the IO initiatives and were able to understand the motivation behind their support, it functioned as a strong driver for overall change. On the other hand, in cases with lack of enthusiastic key personnel, overall enthusiasm and engagement could often be weakened and the IO implementation restrained. In these situations the guiding coalition could attempt to find and change the skeptics. Our respondents reported that skeptics that were given attention and persuaded often became some of the most positive supporters of change, encouraging their co-workers to follow them. The fact that the skeptics were convinced after having been provided with informational evidence sends a powerful message to others that the change initiatives should be embraced by everyone.

Further, most of our respondents brought up the general mechanisms residing in human nature, explaining why change could harvest restraining effects due to an increased state of uncertainty and fear among employees. Employees going through work-related changes might develop a fear of changes in routines/status, or even of becoming excess and losing their jobs (Buchanan & Huczynski 2010; Burns 2009; Cummings & Worley 2009). We found that some of the offshore personnel have felt, and some still do feel, that

IO-related changes might threaten their job situation. The fact that the offshore installations, to an increasing extent, can be remotely operated and controlled by people onshore may create perceptions that positions offshore belong to the past rather than the future.

Additionally, since some employees have been moved from offshore installations to onshore working environments, some of the remaining employees offshore have started worrying. As with their colleagues, a lot of decision making responsibilities have also been reorganised, to some extent creating a feeling of insignificance among the remaining personnel due to the reduction in decision making power offshore. In many instances this has meant that prior to making a decision, an offshore worker would need to consult with the operations centre onshore. We found that this increased level of bureaucracy might have created negative feelings among the offshore employees affecting both their motivation to partake in the changes, as well as their general job satisfaction. Related to this comes the negative effects that emerge with a loss of status. Since more and more decisions are being made onshore, some of our respondents reported a drop in perceived job importance, and thus status, among offshore personnel. Without proper management and focus, these negative aspects can potentially have a damaging effect on the IO implementation process - as well as on the day-to-day operations.

Employee involvement in planning is generally shown to have positive effects on employee commitment (Buchanan & Huczynski 2010; Burnes 2009; Beer & Nohira 2000). In conducting our research, we uncovered a shared concern among our respondents towards the necessity of involvement of employees in planning, execution and evaluation of the IO implementation. This shared concern was based on the different experiences of varying degrees of employee involvement in the respective organisations. In organisations with low degrees of employee involvement, we learned that commitment to change was replaced by mere compliance, and motivation was reported to be low. In the large bureaucratic organisations, IO activities functioned as standardized corporate initiatives. In accordance with change management theory, respondents informed that when employees perceived the decision making and planning to be too much top-down, they felt they were no part of the change process, and that their competence and know-how were not utilised in the optimal way. This could create a sense of carelessness which might have negative effects on the implementation outcome. On the other hand, in organisations with high degrees of employee involvement, we found that commitment and motivation were high. Another interesting finding was that some of our respondents claimed better quality in the actual implementation process in cases where employees had been involved in the planning. In other words, the inclusion of employees functions as a valuable source of input in the development of new IO-solutions.

Technological Solutions

As is quite evident from the description of what IO is and how it affects the working environment for the employees, the technological aspect is important. Well-developed network capabilities are provided by fiber-optic cables on the seabed, allowing for continuous streaming of data between the offshore and onshore installations (Gulbrandsøy et al. 2004). By studying what IO really constitutes, it is not difficult to understand that these network capabilities form the foundation IO is built upon and our respondents recognised this fact. Real-time transmission of data, remote controlling of installations and communication across locations would not be possible without these technological capabilities. Communicating across locations in an IO manner also demands the use of cameras, projectors, high definition television screens and screen sharing – all facilitating for enabling people to work and cooperate without even having to be at the same location.

Moreover, a comprehensible user interface on the technical solutions is essential in facilitating the transition of employees in using IO technology in day-to-day working activities. Our respondents describe that too complicated solutions to some extent have confused the less experienced users. Technological complexity has, on a similar note, acted as a potential restrainer in the implementation process. In addition, technological dependence – the fact that one is dependent on technology in order to perform ones work - has yielded a potential restraining force in the implementation. Whenever a breakdown or technical malfunction occurs, it might generate a lot of resentment and anger since there are no other ways to perform the tasks. The respondents pointed to the significance of proper support and maintenance mechanisms to make sure that the technology works as it is supposed to. This point also highlights the importance for organisations to provide their employees with proper training in the use of new technologies.

Some of our respondents brought up an initial overconfidence in new technology that particularly had been existing among engineers in the initial phases of IO development. The planning and visions of IO might have gotten somewhat caught up focusing on the technological possibilities, and to a certain extent perhaps neglected - or at least did not pay enough attention to - the human aspect of implementing new work processes. Some thought that this overconfidence might have had a restraining effect on the implementation process.

DISCUSSION

In the following we will present a discussion where we elaborate on our main findings in relation to theoretical aspects. We start off by discussing two of the most essential issues of this article, namely resistance to change and employee commitment. Further, a shared understanding of the need for change and the maintenance of the different aspects of the MTO framework will be reviewed. The discussion ends with an outlook on the future development of IO.

Resistance to Change?

Resistance is a natural part of change, and when change occurs it is in our human nature to stick to the past and preserve the *status quo* (Buchanan & Huczynski 2010; Burns 2009; Cummings & Worley 2009). As a consequence, employee resistance to change should be a vital issue for managers and change agents presenting a new order of things. According to Ford, Ford & D'Amelio (2008), change agents have traditionally seen resistance as an obstacle that must be eliminated to achieve change successfully. By removing resistance, or the sources of resistance, the implementation of new programs, structures, systems, etc. is often assumed to progress more seamlessly (Ford, Ford & D'Amelio 2008). However, is it necessarily so that eliminating contrasting views will lead to the best result in a change process? By reviewing theory as well as the data gathered in this study, it is evident to us that instead of merely removing resistance to change, it should be utilised in all stages of implementation (Ford, Ford & D'Amelio 2008; Knowles & Linn 2004; Piderit 2000).

By including different perspectives and listening to different voices, we believe that the quality of the change process can be enhanced. In much the same way as the idea of giving someone the role of the devil's advocate in team working (Nemeth 1986) or actively searching disconfirmatory evidence in decision making (Kray & Galinsky 2003), we propose that utilizing resistance to change is a way to get multiple sources of input to the change process. Further, Ford, Ford & D'Amelio (2008) emphasise the danger of labelling resistance as something negative, since such negative connotations might give employees the feeling of being perceived as disobedient by management. If employees feel their behavior is undesirable

and is expected to be negative for change, it might function as a self-fulfilling prophecy (Ford, Ford & D'Amelio 2008). By addressing these issues, it might be possible to ensure a better and more thorough understanding of the entire process, and this will have the potential of improving the final result of the change initiative.

The question is: How can managers in the Norwegian oil industry go about utilizing resistance to change as something positive? We believe that the involvement of employees in both planning and execution of IO-related initiatives is the best way to capitalise on potential resistance. Not only should employees be allowed to participate, but their thoughts and opinions should be taken into consideration. Burnes (2009) suggests two main activities that help establish and maintain a high degree of employee involvement to change - communication and the process of getting people involved. Regular and effective communication processes are suggested to reduce change-related uncertainty among employees, and ensure sufficient information about the change. Burnes (2009) further proposes that organisations should involve their members and make them responsible for the process, instead of approaching them as objects, or even obstacles, to change. There are, of course, practical limitations as to what extent employees can be involved in planning and execution. Thus, it is important to identify and engage those whose assistance is necessary and those who are crucial in making the change happen.

Considering our case, organisations operating on the NCS, it is difficult to say to what extent employees have been involved in the planning and execution of IO-related initiatives. More specifically, it seems that even though there has been a high degree of involvement, we question to what extent employee contributions actually have been taken into account. Among the change managers and agents, there has been a shared perception that employees have been involved from day one. Among the union representatives, on the other hand, we learned that lower level employees, to various extent, have felt a lack of participation in that their thoughts and ideas have not been heard. In general, when employees are sufficiently involved, it will facilitate high degrees of commitment to change (Buchanan & Huczynski 2010; Burnes 2009; Beer & Nohira 2000). This does not mean that change is impossible without employee involvement, but commitment might in these cases be replaced by mere compliance – creating an unenthusiastic "do as you are told" -state of mind.

Understanding the Need for Change

As presented initially in this article, the companies operating on the NCS are positioned in a lucrative industry where profits are high and operations have been successful (SSB.no). Thus, prior to our research, we intuitively assumed that the organisations would have faced problems in establishing a sense of urgency – a shared understanding of the need for change – among the employees. After all, why change a winning formula? As we interviewed our respondents, we found that there seemed to be a mutual understanding, both among managers as well as employees, of the necessity for implementing IO-related initiatives. There are multiple factors we believe can explain this widespread acceptance for change.

First, visualizing and explaining that IO brings about a more effective way of performing work for the employees have created a broad acceptance. Second, there has been a focus on providing sufficient information about the specifics of IO and its implementation. Such information flow has been enabled by good procedures for communication. Third, we believe a high degree of organisational readiness for change has moderated the need for establishing a sense of urgency, since such a culture is characterised by openness to new ideas. Fourth, we found that many of the managers have utilized theoretical change management concepts

such as, for example, the theories of John P. Kotter (1996). Finally, the implementation of IO is a continuous change process consisting of multiple episodic change initiatives. This gradual development helps to establish a common understanding of the rationale behind change.

Man – Technology – Organisation

Despite the fact that there has not been set specific long-term goals in the implementation of IO, our respondents reported that they would have expected the IO-development to come further than it has today. Also OLF has had more optimistic expectations than what has been realised (OLF 2007). The question is then; why has the implementation been progressing slower than expected? To answer this question, we will have to look at the initial aspirations that were proposed for IO. The new ICT systems introduced in the industry at the turn of the millennium yielded enormous opportunities, and the engineers that were involved in the initial planning of IO might have displayed overconfidence in the effects of the technological possibilities (OLF 2007). This created a focus on the T-aspect that might have come at the expense of the "softer" M- and O-perspectives. If it is true that the human and organisational dimensions have not been given sufficient attention, this might be one of the reasons for an implementation that is slower than expected.

The high level of change management-focus within the industry today might be seen as evidence that the M- and O-aspects were, to some extent, undermined in the initial phase of implementation. This is supported by both our respondents as well as industry-related documents. Successful implementation of IO is seemingly related to an equal interplay between all three dimensions of MTO (Rosendahl & Egir 2008; OLF 2007; Hepsø 2006; Ringstad & Andersen 2006; Herbert, Pedersen & Pedersen 2003).

Future Development of IO

As OLF started working on issues related to IO, they divided the progress into two different stages, or "generations". Generation one included integration between onshore and offshore installations and was expected to take place between 2005 and 2010 (OLF 2010). This was facilitated by the development of operation centres onshore with possibilities to interact with the offshore installations. As a consequence, the organisations would become more efficient by the raised competence and improved decision-making accuracy. The second generation of implementation is somewhat vaguely defined in terms of time perspective, starting in 2010 but with no specific end. This stage of IO-implementation will be more of an ongoing process that involves the integration of operators and supplier/vendor companies, using automation to transform the offshore installations into more intelligent facilities. Including so-called third parties in the work process of daily operations will allow for more competency and faster decision making, since more relevant stakeholders are involved. Within the Norwegian oil industry, the integration of suppliers has already begun, and the trend will continue throughout the following years.

Further, as the NCS, to an increasing extent, is characterised by the use of technology and automation, the second generation of IO will have to involve a better integration of data from different systems (OLF 2008). Operation centers are monitoring a vast array of sensors and parameters on the offshore platforms, and different installations are using different technological systems from different manufacturers and time periods (TU.no). This creates a great concern with regards to interpreting all the diverse data. Thus, there is a need for systems that are able to convert the different data into understandable information. This is a challenge that will require considerable effort.

PRACTICAL IMPLICATIONS

The findings we have presented in this article should have various practical implications for managers, change agents and organisations – not only within the oil industry, but also for the implementation of large-scale change in other industries. First, the specific forces we have discovered through our analysis should be of particular interest to companies operating on the NCS. Since data were gathered across multiple organisations in the industry, there should be a great potential for gaining valuable learning by reviewing the experiences the industry has had as a whole. Second, companies within the Norwegian oil industry are leading in the development of IO on a world basis (Henriquez et al. 2008). Thus, the driving and restraining forces that have effected the change here should be very useful for other oil industries where the implementation of IO is at an earlier stage.

Further, we believe our findings have implications for large-scale change in other industries as well. An increasing globalisation in the business world of today has led to more and more organisations being structured with departmental units in different geographical locations in order to gain a competitive advantage (Buchanan & Huczynski 2010). As the different units of an organisation are being positioned in distant locations, a new and somewhat different demand for communication emerges that, for example, might include a more virtual structuring (Buchanan & Huczynski 2010). Thus, we assume that many companies will benefit greatly from making use of high-tech ICT-systems in order to collaborate effectively across physical boundaries. The findings we have presented that are related to communication and the use of information technology should be particularly relevant in overcoming potential challenges of such an implementation.

Finally, many of our findings speak to change management practices on a more general level. Overcoming what have been referred to as 'resistance to change' has been shown to be a more complex process than many might intuitively think, and there is a need for organisations to define and approach resistance in a sophisticated manner. Also, the establishment of employee commitment to change is indeed a multifaceted process that organisations will have to pay close attention to – regardless of the type of industry.

Limitations

A few limitations associated with our study should be noted and discussed. First and foremost, as with most qualitative case studies, there are challenges related to the operationalisation of the specific concepts (Yin 2009). The challenge of developing an operational set of measures might easily lead to subjective judgements, impairing the construct validity of the study (Yin 2009). Second, the wide scope of this study might be seen as a limitation since not all of the specific concepts are defined and investigated in a sufficiently thorough manner. However, it has been the aim of this study from the beginning to map out the different driving and restraining forces in the implementation of IO, and this task will necessarily demand a certain breadth of perspective. We still acknowledge that the width of our scope has come at the expense of detail.

Third, the fact that IO-related initiatives have been implemented over a longer period of time speaks for the appropriateness of performing a longitudinal study. To measure a continuous change process based on interviews conducted at one specific moment in time might have limitations with regard to the respondents' ability to correctly reflect the past. The documents we have utilised as an additional source of evidence have, to some extent, assisted us in decreasing this weakness, since they were written over different time periods. Finally, questions can be asked as to what extent the findings of our research are applicable for the larger population – which in our case is the organisations operating on the NCS. We have attempted to ensure the generalisability by including respondents

from different organisations, which we believe has increased the external validity of this study. However, research on change management has a general lack of consistency in explaining why so many change efforts fail, and thus we are cautious in claiming validity and generalisability in our findings. In addition it should be mentioned that there are potential short-comings related to Kotter's model of change. Critique centralises around the oversimplification such step-by-step recipes might represent (Langley & Denis 2006) as well as the neglect of organisational cultures' importance (Bate, Kahn & Pye 2000). We personally perceive Kotter's model to be based on a somewhat mechanical foundation, assuming that employee behaviour can be altered by managers through organisational design.

CONCLUSION

Throughout this study we have made an attempt at investigating how change has been managed in terms of implementing Integrated Operations within organisations operating on the Norwegian Continental Shelf. In doing so, we have mapped out what we have found to be important factors driving and restraining the implementation of change. Our findings suggest some specific areas of change management that applies to the Norwegian oil industry in particular, elaborating on previous, current and future issues related to the implementation of IO-initiatives.

We would like to note that even though it seems to have been an initial overconfidence in the effects of IO, we acknowledge that the overall implementation today is relatively successful. As time has gone by and lessons have been learned, an increasing emphasis on the "softer" aspects of change has come into play. However, this does not mean that the oil companies can allow themselves to rest on their laurels. The success of the future development of IO demands a strong emphasis on different change management issues in order for the Norwegian oil industry to gain competitive advantage and stay ahead of the other oil industries. The findings of this study illuminate some of the concerns that will have to be taken into account.

REFERENCES

Andersson, O., & Rollenhagen, C. (2002). The MTO concept and organizational learning at Forsmark NPP, Sweden. Presentation held at the IAEA International Conference on Safety Culture in Nuclear Installations, Rio de Janeiro, Brazil, 2-6 December 2002.

Bate, P., Kahn, R., & Pye, A. (2000). Towards a culturally sensitive approach to organizational structuring: Where organization design meets organization development. *Organization Science*, *11*, 197–211. doi:10.1287/orsc.11.2.197.12509

Beer, M., Eisenstat, R. A., & Spector, B. (1990). Why change programs don't produce change. *Harvard Business Review, November.*

Beer, M., & Nohria, N. (Eds.). (2000). *Breaking the code of change*. Boston, MA: Harvard Business School.

Bennis, W. (2000). Leadership of change. In Beer, M., & Nohria, N. (Eds.), *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Berg, B. L. (2009). *Qualitative research methods for the social sciences* (7th ed.). Boston, MA: Allyn & Bacon.

Bolman, L. G., & Deal, T. E. (2003). *Reframing organizations: Artistry, choice, and leadership* (3rd ed., pp. 367–408). San Francisco, CA: Jossey-Bass.

Bryman, A., & Bell, E. (2011). *Business research methods*. Oxford, UK: Oxford University Press.

Buchanan, D., & Huzcynski, A. (2010). *Organizational behaviour: An introductory text* (7th ed.). New York: Prentice Hall.

Burnes, B. (2004). Kurt Lewin and the planned approach to change: A re-appraisal. *Journal of Management Studies*, *41*, 977–1002. doi:10.1111/j.1467-6486.2004.00463.x

Burns, B. (2009). *Managing change*. Harlow, UK: Financial Times/Prentice Hall.

Conger, J. (2000). Effective change begins at the top. In Beer, M., & Nohria, N. (Eds.), *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Cummings, T., & Worley, C. (2009). *Organization development & change*. Mason, OH: South-Western.

Dunphy, D. (2000). Top-down versus participative management of organizational change. In Beer, M., & Nohria, N. (Eds.), *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Fedor, D. B., Caldwell, S., & Herold, D. M. (2006). The effects of organizational changes on employee commitment: A multilevel investigation. *Personnel Psychology*, *59*(1). doi:10.1111/j.1744-6570.2006.00852.x

Ford, J. D., Ford, L. W., & D'Amelio, A. (2008). Resistance to change: The rest of the story. *Academy of Management Review*, *33*(2), 362–377. doi:10.5465/AMR.2008.31193235

Green, M. (2007). *Change management masterclass: A step by step guide to successful change management*. London, UK: Kogan Page.

Gulbrandsøy, K., Andersen, T. M., Hepsø, V., & Sjong, D. (2004). *Integrated operations and e-fields in maintenance and operation: the third efficiency leap facing the Norwegian oil and gas industry*. Paper presented at the MARCONI Conference.

Henriquez, A., Fjærtoft, I., Yttredal, O., & Johnsen, C. (2008). *Enablers for the successful implementation of intelligent energy: The Statoil case*. Intelligent Energy Conference and Exhibition, 25-27 February 2008, Amsterdam, The Netherlands.

Hepsø, V. (2006). *When are we going to address organizational robustness and collaboration as something other than a residual factor?* SPE Intelligent Energy Conference and Exhibition, 11-13 April, 2006, Amsterdam, The Netherlands.

Herbert, M., Pedersen, J., & Pedersen, T. (2003). *A step change in collaborative decision making – onshore drilling center as the new work space.* SPE Annual Technical Conference and Exhibition, 5-8 Oct. 2003, Colorado, US.

Herscovitch, L., & Meyer, J. P. (2002). Commitment to organizational change: Extension of a three-component model. *The Journal of Applied Psychology*, *87*, 474–487. doi:10.1037/0021-9010.87.3.474

Holt, D. T., Armenakis, A. A., Field, H. S., & Harris, S. G. (2007). Readiness for organizational change: The systematic development of a scale. *The Journal of Applied Behavioral Science*, *43*(2), 232–255. doi:10.1177/0021886306295295

Knowles, E. S., & Linn, J. A. (2004). The importance of resistance to persuasion. In Knowles, E. S., & Linn, J. A. (Eds.), *Resistance and persuasion* (pp. 3–9). Mahwah, NJ: Lawrence Erlbaum Associates.

Kotter, J. P. (1995). *The new rules: How to succeed in today's post-corporate world*. New York, NY: Free Press.

Kotter, J. P. (1996). *Leading change*. Boston, MA: Harvard Business School Press.

Kotter, J. P., & Cohen, D. S. (2002). *The hearth of change*. Boston, MA: Harvard University Press.

Kray, L. J., & Galinsky, A. D. (2003). The debiasing effect of counterfactual mind-sets: Increasing the search for disconfirmatory information in group decisions. *Organizational Behavior and Human Decision Processes*, *91*, 69–81. doi:10.1016/S0749-5978(02)00534-4

Langley, A., & Denis, J. L. (2006). Neglected dimensions of organizational change: Towards a situated view. In Lines, R., Stensaker, I. G., & Langley, A. (Eds.), *New perspectives on organizational change and learning*. Bergen, Norway: Fagbokforlaget.

Lawler, E., & Worley, C. (2009). Designing organizations that are built to change. In Hesselbein, F., & Goldsmith, M. (Eds.), *The organization of the future*. San Fransisco, CA: Jossey-Bass.

Nemeth, C. J. (1986). Differential contributions of majority and minority influence. *Psychological Review*, *93*, 23–32. doi:10.1037/0033-295X.93.1.23

OLF. (2007). *HMS og integrerte operasjoner: Forbedringsmuligheter og nodvendige tiltak*. Retrieved August 19, 2001, from http://www.ptil.no/getfile.php/PDF/IO%20og%20HMS-%20OLF-rapport.pdf

OLF. (2008). *Arena integrerte operasjoner – Smarte sanntidsoperasjoner for oljesktoren*. Retrieved August 19, 2011, from http://www.nce-subsea.no/publish_files/Jan_Krokeide_OLF.pdf

OLF. (2010). *Brochure integrated operations.* Retrieved January 15, 2011, from http://home.hit.no/~hansha/documents/theses/2010/BazeField/Background/Baze/Integrated_Operations_%20Brochure.pdf

Piderit, S. K. (2000). Rethinking resistance and recognizing ambivalence: A multidimensional view of attitudes toward an organizational change. *Academy of Management Review*, *25*(4).

Reger, R. K., Mullane, J. V., Gustafson, L. T., & DeMarie, S. M. (1994). Creating earthquakes to change organizational mindsets. *The Academy of Management Executive*, *8*(4), 31–43. doi:10.5465/AME.1994.9412071701

Ringstad, A. J., & Andersen, K. (2006). *Integrated operations and HSE – Major issues and strategies.* SPE International Conference on Healt, Safety and Environment in Oil and Gas Exploration and Production, 2- 4 April, 2006, Abu Dhabi, UAE.

Rosendahl, T., & Egir, A. (2008). Multidisiplinære team og oljeindustrien – Hvordan implementere Concurrent Design i StatoilHydro? *Magma (New York, N.Y.)*, ▪▪▪, 6.

Rubin, H. J., & Rubin, I. (1995). *Qualitative interviewing: The art of hearing data*. Thousand Oaks, CA: Sage.

SSB. (2007). *Financial results on the Norwegian Continental Shelf 1989-2007*. Retrieved August 26, 2011, from http://www.ssb.no/english/subjects/10/06/20/oljeregn_en/

Whittington, R., & Mayer, M. (2002). *Organizing for success in the twenty-first century: A starting point for change*. London, UK: Chartered Institute of Personnel and Development.

Yin, R. K. (2009). *Case study research: Design and methods*. Los Angeles, CA: Sage.

Yukl, G. (2010). *Leadership in organizations*. Upper Saddle River, NJ: Pearson.

KEY TERMS AND DEFINITIONS

Change Management: A broad term referring to the manner in which organisations or people anticipate change and reconfigure themselves in accordance with constantly evolving surroundings (Lawler & Worley 2009).

Employee Commitment: Commitment is often described as an employee's attachment to an organization, but this association might also have other referents such as an organizational subunit, a supervisor, or even a particular program or event, as for example a change occurring within the organization (Herscovitch & Meyer 2002).

Integrated Operations: The Norwegian Ministry of Petroleum and Energy (St.meld no. 38) defines IO as: "Use of information technology to change work processes to achieve improved decisions, remote control of processes and equipment, and to relocate functions and personnel to a remote installation or an onshore facility".

Resistance to Change: According to Kurt Lewin, resistance to change can be defined as "a restraining force moving in the direction of status quo" (Lewin 1952, cited in; Piderit 2000, p.784) and it might be conceptualized as a cognitive state, an emotional state or as a behavior. Resistance to change is one of many reactions employees might display when introduced to change.

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Chapter 18
Knowledge Markets and Collective Learning:
Designing Hybrid Arenas for Learning Oriented Collaboration

Bernt Bremdal
Narvik University College, Norway

Torbjørn Korsvold
SINTEF Technology and Society, Norway

ABSTRACT

In this chapter, the authors argue that "Knowledge Markets" might be used as a term to describe how individuals can be engaged in a democratic process where their competence, background, and personal information resources are mobilized in full in a broad and non-biased process. The contribution of each individual is aggregated and averaged in a way the authors believe will yield more accurate results, personal involvement, and learning than traditional approaches to group efforts. Recent work on crowdsourcing (Surowiecki, 2004) highlights the strength of a collection of individuals over traditional organizational entities. This contribution will extend these principles to fit into an organizational setting. The chapter discusses how knowledge markets can create an arena for change. Moreover, it shows that if certain principles are observed desired effects could be achieved for relatively limited groups. The authors extend this to propose theories about collective learning and performance improvement. They further describe how the principles defined can help to meet some fundamental challenges related to petroleum activities such as drilling. The authors think that the Knowledge Market approach can serve as a model for designing IO arenas to increase collaboration, to improve shared problem solving, and make collective learning more effective. In all kinds of operations performance improvement is strongly related to learning. It is a cognitive ability that must be exercised and maintained through motivation, discipline, and other stimuli. Collective learning applies to the effort whereby a group of people detect threats or opportunities and learns how to take early advantage of this in order to assure change.

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INTRODUCTION

We claim that a drilling operation is a process whereby change is the norm rather than the exception. Consequently collective learning is an essential ingredient for future success. Collective learning is often described as a collaborative exercise that will involve competence building and knowledge sharing that seek to enhance the individuals' skill and insight as well as mutual understanding that strengthens working relationships, clarifies roles and makes common goals transparent. Integrated Operations (IO) are organized around arenas where collective learning is essential. Arguing in line with Why, What and How learning (Korsvold et.al, 2010) as well as the concepts of exploration and exploitation in organizational learning (March 1991), we have pinpointed the need for a balance between the different dimensions of learning. The Knowledge Market is dynamic and democratized arena that involves all individuals that must be united around a set of common processes. It makes an organization posed for change by making objectives and solution strategies transparent and by combining the cognitive capabilities of the many with individual incentives, knowledge and skills.

Imagine a big jar of jelly beans placed on a table. A crowd of people will be challenged to guess the number of beans that it contains. Each member of the crowd acts independently and is allowed to scrutinize the jar and its content in his own way to volunteer a judgment. To the dismay of some the collective performance of the crowd is likely to outperform any individual among them. The average estimate of the collective guessing will, with a very high probability, be the best. The chances that the crowd's average output will be among the top three estimates, including the best individuals, is very close to one. The experiment can be carried out by anybody, and though it may seem counterintuitive the outcome is persistent. The crowd beats the individual over and over again. This and many other examples that illustrate the *wisdom of crowds* are described in the best seller book carrying the same title and authored by James Surowiecki (2004). Surowiecki argues that crowds have inherent capabilities that can be unleashed in order to find solutions to different types of problems. He points to a number of cases where problems posing a real challenge even for seasoned experts are better off if solved by a democracy of individuals. Such a democracy favors individualism for the benefit of the collective.

A convincing body of both historic and more recent research is mobilized to support his claim. In light of this the most intriguing question is why the application of this know-how has not penetrated more enterprises, both within business and government. Since the inception of the Internet we have seen the emergence of enterprises that thrive on the crowd and whose value is dependent on the number of participants involved in production, marketing and development of the enterprise's offering. Early examples were the Apache Web Server (AWS 2011) and the Linux operating system (Shuen, 2008). Since then we have seen the emergence of digital social systems such as Facebook and Wikipedia. They all rely on the crowd to prosper and many such enterprises have seen their stock value soar. An entire suite of digital technologies under the label "Web 2.0," has emerged to support such systems (Shuen, 2008). Many attempts have been made to "in-source" these technologies in order to create enterprise systems that are meant to support the organization and its members to increase general participation in business affairs, exchange information and share knowledge (O'Reilly and Battelle, 2009). Compared to Internet oriented initiatives, the fruits of intranet or intra-organizational endeavors have been modest. A more recent initiative exploiting the benefits of Web 2.0 technologies and directed towards the enterprise is crowd sourcing (Howe, 2008) and so called digital ecologies (Shuen, 2008). They are both relevant aspects of the ideas presented here.

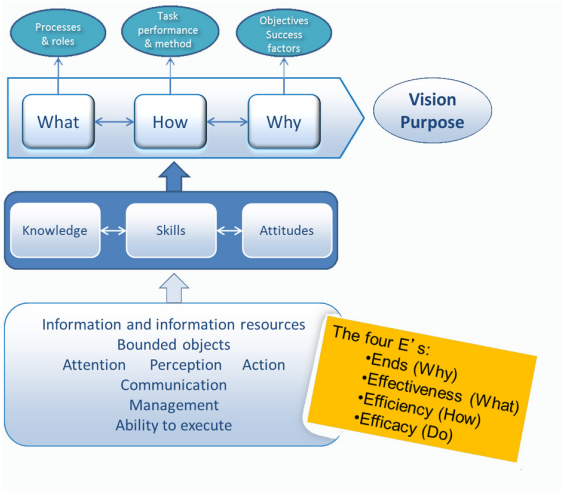
In this discourse we use the term knowledge markets to illustrate a concept of collective learning that we are working with in order to alleviate some fundamental issues of group cognition and collaboration. With support from a number of scientific studies we provide a rationale for why the present mindset and practices in the petroleum industry related to collaboration, learning and problem solving should be revised and not be allowed to penetrate design and operation of IO arenas. Despite the difference in scale we argue that smaller groups and professional teams could adopt certain crowd qualities to excel. Basically we apply all this to describe how a group of individuals can be engaged in a democratic process where their competence, background and personal information resources are mobilized in full in a combined learning and decision process. This is closely related to what we have called Why, What and How learning and which has been discussed extensively in other literature (Korsvold et.al 2010; Bremdal and Korsvold, 2009) (see Figure 1).

While our approach to collective learning through the Why, What, and How concept focused on the framework and prerequisites for improved collective learning, knowledge markets are more directed towards the act of learning within this framework. Using an empirical basis gathered from several domains we have developed both tools and methods to support the planning or assessments of arenas and instruments for collective learning. This has been adopted to suit the petroleum industry. Our emphasis has been placed on drilling and well, but should apply well beyond this field.

THE COMPLEXITY OF ORGANIZATION AND KNOWLEDGE IN DRILLING AND WELL OPERATIONS

Documentation stemming from inquires and lessons learned in the aftermath of the drilling accident on the Macondo field last year clarify and

Figure 1. The why, what, and how (WWH) framework for collective learning



highlight some illustrative and highly important challenges in drilling operations. In one of the reports the Macondo incident is being compared to other recent oil and gas accidents like the Snorre A in 2004 and Gullfaks C in 2010 (Tinmannsvik et.al, 2011). There are some striking commonalities. Deficiencies and weaknesses related to the organization and management of drilling operations are emphasized as important reasons for the accident. Factors like *ineffective leadership*, *poor training and experience transfer* and *inadequate communication and usage of technology* are pointed to as some of the main underlying causes to the safety failures. Some go as far as to claim that the whole industry is a victim of groupthink (Barsa and Dana, 2011). The homogeneity of the community and the degree of peer socialization could have led to norms that failed to question fundamental issues. Another factor linked to the underlying causes and emphasized as a common characteristic of drilling and well operations, is the rapid *increase of complexity* taking place across the industry. A number of implications could be derived from the above. Some major ones would be to leverage the common, cognitive capabilities of the collection of professionals involved in drilling in order to manage the increased complexity.

This in turn would require improved training, more efficient knowledge and information sharing within the collective, improved collaboration and improved collective learning capabilities. Before probing into this we will expand more on the issue of complexity.

In the context of drilling complexity is emphasized along three dimensions:

1. Organizational
2. Technical
3. Management

The organizational dimension addresses the characteristic fragmentation of drilling organizations conditioned by the huge amount of different experts from a set of different companies that interact to various degrees on a limited time span of a costly and risky drilling campaign. In this setting all the experts onshore and rig personnel offshore have to find a way of working together as a united drilling team in accordance with certain efficiency and safety demands. These operational conditions place severe demands on quality of day-to-day collaboration between individuals, disciplines and teams[1]. The decision making processes that have been designed are also placed under pressure because of this.

The technical dimension relates to the continuously increasing instrumentation in terms of far more advanced distant and real time technology to retrieve the necessary drilling data and information in more complex reservoirs. The aggregation mechanisms are currently too weak to yield sufficient and unbiased overview of a problem or situation.

The third dimension of complexity relates to the capabilities required to deal sufficiently with processes and management of change. A fact which is sometimes ignored or suppressed is a key characteristic of the drilling process itself. A drilling operation is in many ways a *continuous process of change* that constantly needs to respond to shifting and unexpected situations. Deviations from the drilling plan is more or less a persistent phenomenon. The collective drilling effort can be viewed as a constant act of rebalancing. Search for new solutions and creation of new knowledge must be weighed against exploitation of existing expertise. An organizational equilibrium must be met that optimizes chances of both short term and long term adaption.

Empirical studies that we have performed as part of our research at the Centre for Integrated Operations (CIO) at NTNU, (Letnes and Korsvold, 2008) underpin the Macondo findings and conclusions in highlighting the more concrete deficiencies of organization and management of today's drilling organizations. Of particular relevance here is the inadequacy of information exchange, common learning and understanding in groups and organizations both offshore and onshore.

Findings in our IO Center research (Korsvold et.al 2009; 2010) also show that it is difficult to communicate between different disciplines located at different places around the rig. This is largely due the fact that the flow of information can be easily distorted and that rigid procedures prevent critical and creative thinking. This finding points to the need of establishing improved balance between use of procedures in drilling and using the drilling team's own competence, capacity for experience transfer and autonomous team evaluation.

We have also made observations that decisions-making processes are too slow and without a holistic approach of the drilling process. This deficiency is particularly evident when multiple problems arise. This leads to insufficient generation of alternative solutions, poor utilization of available information and bias in choice. Cognitive limitations make the aggregation task extremely demanding. Deficient access to realistic and dynamic models for real time "forward-looking" and "what if" evaluations is also problematic. It hampers the capacity of the drilling team to learn about the drilling process as a whole and thereby also to optimize it. In terms of IO initiatives all

of these challenges pose problems that require special attention (Moltu and Nærheim, 2010). Similar observations have been made by Haavik (2011). Several of the identified issues *are likely to be affected, but not resolved* (op.cit. p.6) in an IO change process.

We hypothesize here that the issues and challenges that drilling operations are faced with are fundamental to all types of operations requiring a collective effort. Above all we believe that many of them are rooted in the ability to learn and to adapt as a group of individual or as an organization. Change must be rooted in new insight obtained from theory or experience. Previously we have created a framework for collective learning that we have called the 4xE Method (see Figure 1). The method provides a means to specify and analyze arenas and tools according to three learning dimensions Why-, What- and How- (WWH-) learning (Korsvold et.al 2010). This work has been described and developed in cooperation with the Centre for Integrated Operations (CIO) at NTNU in order to create a foundation for IO based drilling operations. The essence of WWH-learning can briefly be described as a balanced and comprehensive understanding of the teleology, the effectiveness and the efficiency of a task that needs to be performed. While our former work has been concerned with the functions of arenas for collective learning we are currently pursuing new arena concepts and tool designs based on this. The basic question asked is how we can organize a collection of professionals so that efficient WWH-learning and collaboration can take place. We have found a significant body of historic research that addresses issues that we have described above. This research can largely explain the reasons for many of the challenges that drilling operations have been faced with and that are likely to be amplified with the introduction of IO. Based on this research we have constructed the market analogy as a proper model for collective involvement, decision making and collaborative knowledge building. Our aim is to show, through our ongoing research in CIO, that the knowledge market defines an arena for collaboration and change that is inclusive, cognitively more sound and with a potential to liberate IO based drilling operations of the weaknesses that have been identified.

THE PROBLEMS WITH EXPERTS, SOCIALIZATION AND GROUPS

Introduction

A lot of the issues discussed above is related to the tension that exists between do and learn in a collective. As discussed above several of the problems can be traced back to management, collaboration and the role of the individual with respect to the collective. They introduce cognitive challenges related to information management, knowledge sharing, decision making and expertise. With this backdrop we will highlight some 40-50 years of scientific research that we believe is highly pertinent to the issues faced with in the petroleum industry and in turn the design and operation of IO centers.

Exploitation versus Exploration

In 1991 James March published his seminal paper on exploration and exploitation in organizational learning (March, 1991). Given that drilling operations can be viewed as continuous processes of change and that equilibrium must be established between search for new solutions and exploitation of the established body of knowledge this work of March is fundamental to understand. The model that March presents provides a direction on how to compose small and large organizations to enable this. But it also tells us how we can take advantage of the hybrid nature of a drilling operation with its diverse set of professionals and contractors.

March had drawn inspiration from studies of adaptive processes in nature (Holland, 1975) and

economics (Schumpeter, 1934) to show how organizations must maintain a balance between exploitation and exploration to survive and prosper. In this context exploration is associated with search, variation, risk taking, experimentation, play flexibility, discovery and innovation. Exploitation, however, pertains to such things as refinement, choice, production, efficiency, selection, implementation and execution. A system or organism that throws all its resources into exploration will suffer the costs of experimentation, but harvest none of its benefits. The result will be undeveloped ideas and little distinctive competence. The other extreme, where only exploitation is maintained, will lead to a locked-in situation where all options are exhausted and resources eventually depleted. Adaption and survival requires both. The extent of environmental change determines the degree of trade-off between the two[2]. In the context of Why, What and How-learning (Korsvold et. al. 2010) reflections related to why certain objectives are aimed for and the rationale behind these holds a larger explorative potential than any learning along the two other dimensions. Both What- and How-learning have more narrow scopes, are less risky and yield relatively lesser transformational impact.

Organizational learning is also a question of generalization versus specialization. John Holland (1995) states that in a stable and rigid environment a specialist system will be superior to the generalist. Exploitation will always produce immediate and certain benefits. Optimizing and maintaining what the organization already knows is the true essence of exploitation. The importance of this is highlighted by the phenomena of unlearning. Improved practices through learning and improvement initiatives deteriorate back to prior practice. We have what March calls "slow learners." Slow learners are often a byproduct of low attendance. As the pace of environmental change increases the generalists will gain an advantage. Due to increased diversity there lies an inherent robustness in this. This is what Ragnar Rosness (2001) calls organizational redundancy. Diversity makes an organization better able to handle the unexpected. In drilling, where focus on change and adaption is so pronounced this is therefore very essential.

Organizations can diversify in more than one way. However, knowledge building is but the most important. March illustrates this brilliantly through his model which perceives organizational learning as a dual process driven by both exploration and exploitation. More precisely March shows how this is a dynamic relationship between individual learning and organizational learning.

Organizational learning is enabled by individuals who perceive reality in their own particular way. Socialization is meant to share and synthesize individual beliefs. A refined collective output creates what March calls the organizational code. The organizational code is in turn imposed on the individual in different forms i.e. instruction, indoctrination, exemplification, languages, heuristics and practices. Once individuals defer their own independent perception of the world in order to conform to the code the balance is pushed towards more exploitation. This process accelerates with time as people stay with the organization and no new members enter. Instrumental in creating organizational change is what March has denoted The Superior Majority Group. The superior group is more in line with reality at a given time than the code itself and the rest of the organization. However, the organizational code is likely to be inert to new beliefs if the Superior Majority Group is inferior in number[3]. The more individuals that share the superior majority belief the higher the likelihood is that organizational learning will take place. As the organization grows older and no recruitment takes place there will be little difference between individual beliefs and organizational beliefs. The impact of the Superior Majority Group will decrease and eventually the organization becomes more inert to external stimuli. The problem is likely to be amplified if the code is dominated by experts "boasting a record." Peer influence and information cascades

may also make the issue more pronounced. In a way individualism is seen as an evil. Experts are good, socialization is even better.

In fact we believe that a more balanced perspective is required to overcome the challenges that lie ahead. Individuals represent the greatest asset of a company as they have the ability to see, hear, perceive and communicate in their own particular way and according to their own specific interests and knowledge. In situations or periods where things change rapidly it is important that the Superior Majority Group in the organization is not crippled. Socialization is important when it reinforces the aggregating function that bring individuals beliefs together to form a decision or learning basis. It must not replace or reduce the aggregating function in any way. Two key questions that a change oriented organization will have to ask themselves are a) Who is our Superior Majority Group? b) How do we aggregate input to enable sound change?

The core organizations of oil companies are predominantly what Mintzberg call professional bureaucracies (Mintzberg 1983). As we have pointed out above for the oil industry highly skilled professionals are hired and trained to support the body of work in the value chain. The experts are given a fair amount of control over their own work and work largely independently. As is well recognized for oil companies the professional bureaucracy emphasizes professional authority through individual expertise. The organizational structure is rather inflexible. It is well designed to produce standard outputs, but poorly suited to innovation (Mintzberg 1983). To compensate for this managers in such organizations have introduced ad hoc organizational entities giving rise to various forms of matrix organizations. In the petroleum industry the extreme version of this has proven very successful. The giant project organizations that have been established to deal with the complex challenges that field development in the North Sea has posed and spun out of a group of companies have proven highly adaptable, able and innovative. Fields like Ekofisk, Troll, Åsgard and Snøhvit, all represent major industrial breakthroughs in the history of the North Sea based petroleum business. These are examples of organizations that were built to learn and innovate. The novelty of the problem at hand demanded an extreme focus on exploration before any exploitation could take place. The Code was basically non-existent and the Superior Majority Group was relatively much bigger. Lessons from the project organizations should be channeled into main stream organizational development to address the two important questions raised.

Teams

Drilling operations are typically organized around a collection of people called teams i.e. drilling teams, well intervention teams and similar. This organizational entity has typically emerged to expand and soften the stringency of professional bureaucracies. Teams of various sorts are also emphasized in the context of IO and IO design. Co-location of expertise is a mantra. Teams are often introduced to overcome some of the shortcomings of the professional bureaucracies and to solve certain problems. Teams are also used as a reference for professional groups of people that are meant to conduct certain tasks that are too complex or extensive for a single person to undertake. Teams adhering to well defined routines and specifications can be extremely efficient. Let rowing in the Men's 8 class be an image of the ultimate coordination and execution of teams. In terms of exploitation teams can be top performers. In terms of problem solving, collective learning and the full aspect of exploration some questions need to be asked. The theoretic concept of a team carries with it some outstanding qualities that are both appealing and powerful enough to have the potential to alleviate many of the issues addressed here. Teams share many of the same qualities as a full blown organization and obey the same rules of organizational learning as March

describes. However, in practice what are called teams are no more than a regular group of people. There is no way a team can be declared. It must be crafted. The general notion that half a week of outdoor scrimmage will create a team is false. What is often promoted under the label "team building" has therefore nothing to do with the investment in training and discipline that a true team requires. Ringstad et al. (2008) stress that a significant development period is required in order to transform a group into a team. They emphasize that team work is committing, demanding, costly and hard to achieve.

Well working teams are highly autonomous. They have sufficient decision powers to act when the occasion is there. The team manages its own resources and has clear boundaries with respect to any other principal organizational entity that it may be associated with. Team members must share the same goals, the same requirements and standards for the work which should be performed. Ringstad et al. also stress that team members should represent different competences, skills and experiences. Ideally they should display different personal characteristics. Teams less than 3 and more than 10 members tend to be dysfunctional. In any event teams are fragile. A team's capabilities can deteriorate or be jeopardized when a member quits or is replaced.

Many of the so called teams that we have observed in the petroleum industry violate several of the maxims drawn out here. In fact they tend to operate under an illusion, expecting the performance and results of a team, while the necessary prerequisites for such are ignored. Instead they are left with a group of professionals that may cope, but that will generally fall short of the targets that are required. Certainly, we know of recent initiatives that are determined to pursue the team ideals spelled out here[4]. But our principal claim is that the majority of the so called teams do not obey the "laws of the team." As many organizations then rely on mere groups they tend to fall prey to some profound issues that can explain the deficiencies and weaknesses that have led to some of the major accidents and the uneven performance often experienced in drilling. These deficiencies are well known and properly documented across several decades. In fact we find it surprising that this type of research has not penetrated main stream operations more than it has.

The Expert Trauma

Making teams work is not the only problem. The sometimes naïve faith in expertise is another. Professional bureaucracies like companies that are "knowledge organizations." They employ highly skilled and knowledge people. Many of them are true specialists in their field with a high degree of in-depth knowledge and with splendid CV's that can document years of operational experience and formal education from well recognized universities. If this is not enough the oil business is dense with consultants hired to provide advice on everything from strategy to interior design. The oil business is truly expert driven and expertise is believed to be the key to success in all respects. Scott Armstrong (1980) is not so sure, at least when it comes to prognosis making, certain types of diagnosis and forecasting. And to support his "seer-sucker theory" there is a lot of scientific evidence. Most of this evidence comes from the field of finance, but research has also been done in psychology, economics, medicine, sports and others. They all point in one direction, namely that ordinary, informed people will perform equally well or even better than very knowledgeable people at prognosticating something.

The bearing arguments in the "seer-sucker theory" are that experts grow too confident in their own knowledge. They tend to extend the application of their knowledge and insight beyond its limits and often fail to be receptive of other viewpoints. Scott-Armstrong argues that experts see what they expect to see and are persistently

blind to unfamiliar relationships and patterns. They tend to maintain a strong bias towards information that agrees with their commonly held hypothesis and rejecting the one that contradicted this. Consequently they are resistant to new insight that does not have an apparent bridge to their existing body of knowledge. Scott Armstrong states (1980):

The greater one's feeling of expertise, the less likely that disconfirming evidence will be used.

Many of the negative aspects of the "seer-sucker" theory can be greatly amplified if expertise is combined with formal authority or allowed unduly attention at the cost of others. A study made already in 1958 (Strickland, 1958) showed that managers that maintained a close relationship with a particular employee and supervised this person would rate this person's work higher than others despite the fact that all contributions held the same quality. Moreover, the manager would attribute the performance of the former to his own management skills.

But no oil company can do without their experts. Sunstein (2004), Shanteau (2001) and Rosenthal and Hart (1991) are among those that argue that experts need to be assigned distinct roles and tasks to benefit the organization well. Their negative qualities should be suppressed. The effect of their insight should be amplified. In other words organizations must use them correctly. This is how James Shanteau (2001) puts it:

Using their knowledge and experience, the role of the expert is to recognize patterns and find consistencies in a dynamic problem space. The expert's job is to clarify the issues for the client. In other words, the challenge for an expert is "to make sense out of chaos.

Moreover experts in groups tend to create synergies that outperform other groups provided that such groups are used correctly. Unlike most people Shanteau claims that experts in most any field bypass items of agreement to focus instead on disagreements. Thus, experts view disagreements as a normal part of their job. Disagreement is often a prerequisite for learning. Unfortunately many managers see disagreement between experts as a problem as it tends to delay decision processes. Furthermore, lack of consensus between knowledgeable people is seen as a sign of uncertainty and even an organizational weakness. As experts are meant to be the most important assets of knowledge oriented organizations they will also be main contributors to the Code, as March puts it. Disagreement is the "gentle sister "of"conflict" and are shunned by most managers. Consequently the group or the organization's ability to maintain a proper degree of exploration the way March defines it is greatly reduced.

Rosenthal and Hart (1991) have studied the role of experts in different forms of crisis. One of their main points is that there should be distinct *demarcation of responsibilities between crisis decision makers and expert advisors*. A principal rationale behind this is that decision makers wish to have usable expertise. Expertise is evaluated according to multiple criteria. Professional expertise happens to be only one of them. Rosenthal and Hart observes that professional advice will not necessarily lead to good decisions just as unprofessional advice will necessarily lead to fiascos. The point to be made here is that experts would want to provide an in-depth judgment or analysis on a particular issue. All tend to speak of "the elephant." But some see the trunk, some see the ears and some see the right leg. The unified image is often lacking. Obviously it is imperative to put the different pieces together in order to gain a holistic view. Aggregating different views and information is challenging. But if regular employees were also assigned specific tasks of information gathering and monitoring the aggregating task at the problem solving end could be made a lot easier.

PEER INFLUENCE

Peer influence is another aspect that can determine the influence of collective behavior and hurt the balance between exploration and exploitation. A large body of research can be found on peer influence. According to Voydanoff and Donnelly (1999) people in Europe and the US spend an ever increasing amount of time each day in the company of peers. Much of our adult life is spent at work. In some domains like the offshore oil business it gets as high as 100% for extensive periods. In such cases people tend to substitute normal family life with social relationships developed through work. Though such relationships might vary significantly[5] they all represent very important secondary structures within such organizations. Some managers tend to address their organization rhetorically as "family," the work place as "home" and colleagues as "friends" typically to stress the strong bonds between employees and their loyalty to the enterprise. This type of rhetoric emphasizes social responsibilities and benefits, but also the importance of consensus and adherence to the group.

In terms of collective learning peer influence is not always for the good. Peer conformity can develop into peer pressure. The very thing that you want to achieve through socialization can turn against it. Peer conformity at organizational level can be strongly associated with the organizational code the way we described it before. However, it suggests something more than inertness to outside impulses. It implies a defense mechanism. Defense of the social structures that bind peers together. Information and new know-how that suggest change may be perceived as threats to roles and peer relationships that an individual thrives on, not only as an employee, but as a complete human being. Peer pressure may be exceeded on the individual through the organizational code as a cultural aspect. But a single individual can place similar pressure on another using the code as a reference. The latter is especially pronounced in smaller organizations and groups. Group pressure may give rise to negative information cascades. Group thinking is yet another expression of this. Experts or people with a certain formal or personal authority are more likely to be in a position to exceed pressure on others within a social group of the kind discussed here.

Groups versus the Individual

Teams are groups, but groups are not necessarily teams. Since we, in this discourse, refer to teams in accordance with its theoretical definition most so-called teams offshore and onshore will be treated as mere groups. Although groups may have a strong operational focus, discussion is thought to be the strongest instrument of coordination. Consequently we will also refer to them as deliberating groups.

Unlike the theoretical concept of a team, groups are often less formal organizational entities than the section or the department. A basic idea is to harvest synergies. More brains perform better than a single one. That is the prevailing belief. Groups bring different competences and people together to solve a problem, analyze and issue or perform at set of tasks. Groups may be less stringent on diversity than teams and more liberal in terms of number of members. Under the disguise of the team label, groups have often been looked upon as the holy grail of problem solving and coordinated action. The idea seemed to penetrate every aspect of society. Groups and teams were the answer offered when something was at stake. Sometimes the rhetoric took on a military lingo. Groups became squads and task forces. Even our children could no longer do their homework alone. They were pooled together, instructed to avoid conflicts and taught to seek consensus. Although some of the hype is gone, group work is still very much in vogue in many aspects of life. The organizational psychologists, Paulus and Van der Zee (2004) state that there is significant objective evidence that simply does not support

the favorable perception of groups. According to them even the effectiveness of teams is overestimated. An extensive bibliography addresses the subject of group work and provides significant support for the view of Paulus and Van der Zee. For some references see Sunstein (2004), Baron (2005), West and Slater (1995) and Janis (1977).

According to West and Slater the strength of groups versus individuals in a series of tasks can be seriously questioned. Paulus and other researchers illustrate this with research done on group brainstorming. A lot of research shows that groups do not perform better than comparison groups of individual brainstormers. They even do worse. The efficacy of groups and teams can really be questioned. A number of elements tend to ruin the performance of groups (and in fact teams). One is lack of trust. Failure to create a common and a safe environment for its members is the other. Paulus and Van der Zee (2004) sum it all up:

In order to attain the benefits of group interaction, to reach creativity and innovation, groups need to use the different expertises and insights from group members. This requires a continuous switch among group members between a focus on what joins them and a focus on what makes them unique.

In many ways this is restating the principles offered by March (1991) when he describes the challenges of the formal organization related to exploration and exploitation. Paulus and Van der Zee claims that groups that are not successful in reaching a state of trust risk an emotional conflict between members. In the opposite case groups will seek consensus too early and not explore the different insights of group members. Group thinking is thus imminent. Groupthink is an issue that has been addressed widely with groups and organizations within domains such as politics (Janis 1972), law (Sunstein 2004), the military (Johnson 2001), finance (Bretton Woods 2011) and aerospace (NASA 2008). The subject has also been treated to some extent in newer literature on IO and drilling (Haavik, 2010; Davis, 1998). In the aftermath of the Deepwater Horizon disaster in the Mexican Gulf substantial indicia points to groupthink as a partial cause (Barsa, 2011). A significant body of research can prove that good will is not sufficient to make teams outperform the individual. Ian Janis work (1972, 1977) addresses a number of things that can be attributed to group thinking and which makes groups and teams dysfunctional. Although other organizational psychologists have challenged the antecedents of groupthink (Baron, 2005) that Janis originally formulated, there is hardly any disagreement that groupthink can make people turn blind to new information and alternative opinions. In turn this can lead to faulty or even irrational decision making. In fact Baron argues that groupthink is far more mundane part than Janis anticipated. Although cohesion in groups was originally believed to be a main cause for groupthink Baron places emphasis on conformity:

Individually and correct opinions will often be verbally suppressed when a unified consensus voices an opposing point of view (Baron, 2005)

He also argues that group members who express deviate opinions get initially pressured, then ignored and sometimes punished for failing to conform to salient group norms. Group polarization happens when group discussions take place. Members of a group end up with more intensified attitudes after deliberation. In such cases biases to certain information and input are likely to develop. Discussions within a group can impose self-censorship and reinforce pre-mature consensus. When members realize that the group shares certain beliefs and information, input that members have that do not support this, can be withheld or suppressed. The shared aspect becomes disproportionally amplified. According to Baron, illusions

of consensus and pluralistic ignorance are other characteristics of groupthink. Members of a group will convey and endorse beliefs that they privately disagree with because they assume these beliefs are representative for the group. Each individual therefore winds up assuming that a group is more united on an issue than is actually true. When a group expresses what Janis calls "excessive stereotyping," that is when the group constructs stereotypes of rivals to enforce unity and loyalty we see a very pronounced expression of group thinking. Associated with this is an illusion that the group is both morally superior and invulnerable. With this follows that a group becomes too optimistic and starts to take greater risks. Critical, ethical assessments of own decisions or actions are ignored. Consequently groupthink will also result in uniform discredit of different points of view and warnings that runs counter to the group's beliefs. Based on a diverse set of studies Baron converges on three main causes for groupthink. One is social identification with the collection of individuals that may constitute the concept of a group. Baron refers to studies that indicate that "in-group" messages will trigger more attention than those attributed to members that are not associated with the group. Salient norms are also pronounced when groupthink occurs. Norms can be imported or developed within the group. Philosophical and attitudinal homogeneity in groups can manifest beliefs as normative directions that are acknowledged as unquestionable axioms for all other thinking. In practice this is similar to the part of an organizational code that is never revised, despite changes in the surrounding realities. The third cause is low situational self efficacy with group members. Faced with circumstances that pose a challenge, confidence in their ability to reach a resolve may be severely weakened. This self efficacy can be influenced by such things as decisional complexity, fatigue, negative social feedback or priming.

West and Slater (1995) also question the intrinsic value of teamwork in achieving effectiveness in work organizations:

While it seems plausible that services can be delivered more effectively where professionals work together in a coordinated, coherent way, research evidence indicates that teamwork is very difficult to achieve.

This is very much in line with what we stated earlier. Despite the investments in creating a team the caveats described above are constant threats, even more so then to a simple group. Regarding decision making West and Slater point to research evidence that consistently concludes that the quality of group decision making is poorer to that of the most able members. The participants with pertinent contributions into the decision-making process may often refrain from sharing this. Input volunteered might be ignored. According to West and Slater this can be attributed to lack of confidence, inferiority or lower status. All of this can again be firmly related to the points that Janis and Baron make.

Information Cascades

In his book John Surowiecki (2004) provides an excellent description of information cascades and what causes them. Sunstein (2004) provides a similar discourse on the subject and a very illustrative example that highlights how cascades can arises. Information cascades happen when people make choices based on what others do or say rather than trust their own opinion or sources of information. This is of course strongly related to peer influence and group pressure, but does not need to arise in the context of what we think of as groups. There is usually a professional or social context involved, but it can be open-ended. Cascades often occur as a sequence of events fueled

by people who share their beliefs across a diverse set of relationships that together constitute a very large network. Cascades are strongly related to fads where exponential effects related to some seed information can occur. A cascade can be deliberately invoked and often is by clever marketing people. But it is often triggered unintentionally because people have to make choices and tend to seek support in others to make such. To illustrate this we can use an example on books. Assume that there are two books out on the market. Both have received very positive critics. Book B may even have some additional qualities that Book A does not have, but this may have missed general public attention since both are obviously very good. The question for many is which one do I read? The natural thing to do is to ask someone. This is commonly done. If this pioneer happened to have read A and found it to live up to the literature critics there is often a greater likelihood that the person who asked will buy the same even if he gains the additional information on B. If his conclusion about Book A is the same as the first reader he will probably convey a similar advice when someone seeks his opinion. A propagating effect will occur. Book A is likely to become the new best seller while Book B will pick up sales slower even if it is objectively considered a better book. It all started because we place faith in other people's opinion even if these oppose objective information given. Cascades can in similar ways cause quite the opposite effects. Communication and biases can hurt an operation. One type of example is what happened prior to the crash of "Dana Viking" in Stockholm in 1991 (SHK 1993). Before take off it was evident that ice had settled on the wings of the SAS machine. Investigations unveiled that people had seen this before departure. They also knew what problems ice on the wings could cause. They still believed that things were okay since a message was passed around that the plane was ready to fly. People put more trust into messages given by their peers. Evidently the message that circulated was a byproduct of poor communication somewhere down the line.

Renewed Focus on the Individual to Enhance the Collective

Over the past ten years literature on knowledge management (Gottschalk, 2005; Davenport and Prusak, 1998; Senge, 1990) has praised knowledge sharing as a social act, the very kingpin in organizational learning. Yet based on experience from several projects and a decade of work as knowledge management advisor we are convinced that there are certain norms and beliefs that need to be revised in order to make further progress. This general overview should be extended to the petroleum industry where new focus has been placed on the performance of the collective both in terms of cognition, coordination and cooperation. Teams, standards and practices stemming from traditional operations are extended and adopted to suit integrated operations. In response to the deficiencies unveiled in the course of the investigations carried out at Gullfaks C and Macondo we once more see some fundamental problems that we have discussed here being met with old practices. We do not reject the idea that better training of teams, better management and increased knowledge sharing in the form that we have come to know it over the past ten years can improve things. However, scientific evidence that we have elaborated on suggests that it can be hard. Based on this evidence and our own observations in different business environments we have created some maxims that we believe should be emphasized:

- Individualism is good
- Individuals must relate to the four E's of collective learning (Ends, Effectiveness, Efficiency and Efficacy) to optimize their performance
- Disagreement between experts is good

- Collective diversity and individual independence are keys to increased performance of the collective
- Organizational turnover is good
- Management focus should be placed on The Superior Majority Group
- A collection of individuals can outperform the deliberating group
- Aggregation is more important than socialization
- Decision makers must be aggregators more than social coaches
- Management in a learning organization is about monitoring and ensuring the equilibrium between exploitation and exploration in face of the rapid changes that occur

Several of the points that we have listed contrast some of the traditional views and practices maintained in the oil industry and beyond. But they precipitate as natural consequences from the scientific evidence that we have discussed here.

Individualism is good because it recognizes a person, regardless of profession and work for the cognitive resource he or she is. This is the true essence in crowd intelligence (Surowiecki, 2004). To resonate with reality and to interpret the world and to form new solutions we need as many eyes and ears as possible, as well as insight and ideas. Using March once more as a guide it is important to note that our aim is not to recruit a big crowd so vividly advocated by Surowiecki. It is more important to seek independence, in a sense similar to that of statistical independence. Then the high numbers become less important. Diversity and independence in terms of awareness and perception are most important. If those are assured, it can be shown that even smaller collections of people can do the job of a crowd. In essence the basic objective is to create a superior majority that is sufficiently large and agile. Candidates for this should be recruited within and beyond the company. Currently our research suggests that virtual arenas are more potent in the long term to maintain a superior majority poised for change than the traditional ones found in the physical world. IO Centers should at least be reinforced with a kind of digital peer network.

The traditional answer to collaboration and collective problem solving has been the group, the team and similar organizational entities where focus on socialization and consensus have been very pronounced. But as we have pointed out, here lies a liability that seems hard to work around. In a group stronger individuals and the organizational code are likely to reduce the sum of individual contributions. People tend to suppress what they observe and know in order to secure social acceptance, observe peer loyalty and assure management recognition through consensus and focus on what binds rather than the elements that separate. In order to optimize agility in terms of situational awareness, perception and idea generation individualism must be combined with a high degree of omnipresence and clear-cut incentives for the individual. In recent years we have seen how new technologies can enable the individual in this role. The use of Twitter (www.twitter.com) and Facebook (www.facebook.com) to channel in pieces of information and insight from local spots and to mobilize a resistance that in the end outperformed established regimes is but one example. A degree of individualism is not less suited in the more actionable part of work. Groups of individuals are able to coordinate and cooperate themselves in both formal and informal situations every day without a centralized unity acting upon at all times. A study of soccer should illustrate this. The way online players in games like World of Warcraft (http://eu.battle.net/wow/en/) conduct themselves is also a case in point. But for this to be successful when exposed to quick changes certain skills must be developed. Each individual must adopt a particular role. This must be distinctly defined with respect to what long-term purpose is going to be achieved. Policies and rules must be transparent to all. The responsibility assigned to the role determines how the individual should act

upon a stimuli emitted from the environment and others. Individualism requires that each person is able to understand the ends that should be met, to what effect they should be met and to minimize the use of time and resources in order to fulfill the tasks necessary to achieve them. Lastly the individual must be confident about the role and believe that he or she is able to make a difference.

Role assignment is especially important when employing recognized experts. As highly regarded knowledge workers and specialists in their field they are individuals per se and trained to behave and talk like one. Their strength lies in articulating what they believe in and stand-by it. As pointed out earlier they tend to seek confirmation of what they already know rather than a more objective perspective and are therefore less suitable in the awareness and perception role. Bringing experts together create controversy. Disagreement is basically sought, not avoided. Experts should be used to analyze input gathered. To avoid subjective biases experts should not be decision makers, not even aggregators. Experts often demonstrate an intellectual authority that can make other people hold back on what they know or have observed. Consequently negative peer influence is imminent. Independent views are prime assets and must be secured. Associated with this we will emphasize diversity. Diversity and independence are two aspects of the same thing. Too much overlap in terms of insight, background and company culture may limit the perspective on the environment, cripple the formulation of an issue and hamper a wider exploration of the solution space. As people get to know each other and the group or organization that they are assigned to will develop a common code that eventually will work against the learning excellence that we are seeking. Consequently a degree of turnover in terms of people will contribute to maintain diversity as emphasized by the model created by March (1991). Diversity can also be secured by engaging aliens, outside people that see things differently and inherently play the roles of the devil's advocate and the mind jumper.

In our introduction we briefly described the qualities of a collection of individuals, or what is called a statistical group. As long as individuals in such a collection can maintain their independent views and be a little knowledgeable the way Scott Armstrong (1980) defined it, it can be proved that such groups will perform well. Some emphasize that this may be limited to true-false or factual problems only (Sunstein, 2004). Normative issues may not lend itself well to a statistical group. We are not sure. By means of experts normative issues may be translated into simpler problems that will be easier to address. Besides methods like "Means-Ends" and "Generate and test" (Newell 1982) cater for a breakdown of the challenge so that people may first address possible interpretations of a problem, suggest solutions and test criteria so that both the problem space and the solution space can be explored in steps. For this to work the independent input must be aggregated. In the simpler cases the aggregation is a simple function that adds up and averages the input received. To maintain interest a competitive element should be introduced and participation should be rewarded. Aggregation is a management task and should emphasize participation, accumulation and feedback more than regular socialization. Decision making is the ultimate aspect of the aggregating function. It should be transparent for all that takes part. The whole idea is to let management concentrate on two things, to assure commitment to the task at hand by encouraging a diverse and independent participation and to assure that equilibrium is maintained between exploration and exploitation at all times. This calls for a type of situational awareness that must be able to detect events and changes in the environment very rapidly. Consequently it calls for a rapid switch between specialized and predetermined work to capitalization on a general and diverse body knowledge and information that can revise this work pattern both in the short term and very often in the longer term. This is the true essence of collective learning.

In our previous effort on Why-, What- and How-learning we have outlined a set of provisions, both structural and procedural that are necessary to create a proper arena for collective learning. These include requirements for what to do in order meet objectives, need-to-know concerns, and maintenance between purpose, process and tasks, management of information sources and others (Korsvold et.al, 2010). To design a well functioning arena for collective learning to fulfill all of these we have pursued a set of analogies trying to find one that lends itself to the principles uncovered. The model that best captures all of this is what we call a "Knowledge Market" and which constitutes our current research.

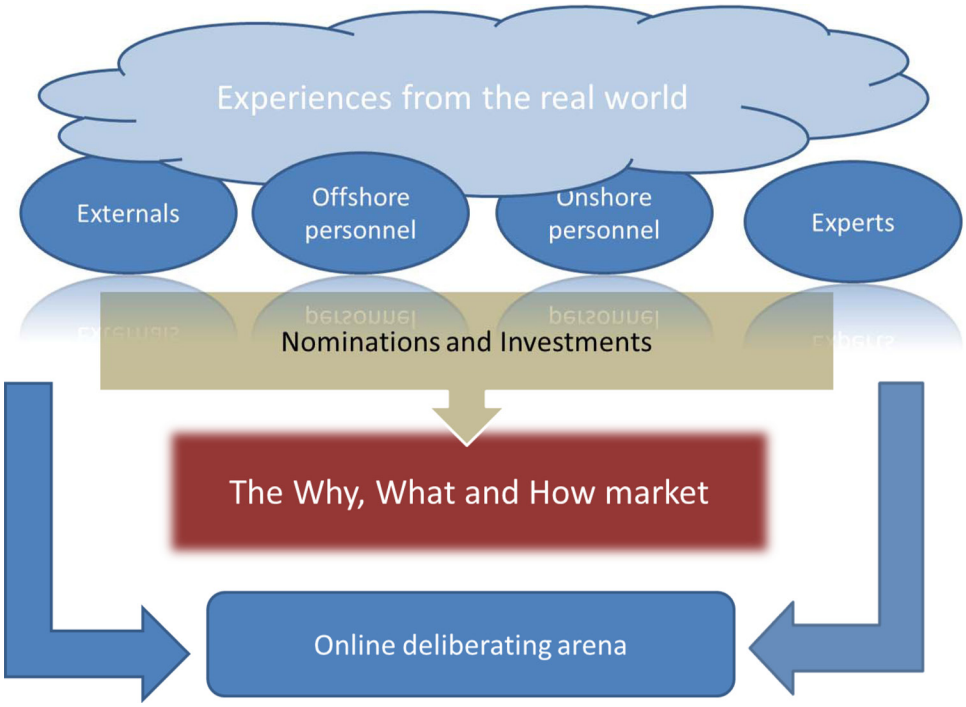
FUTURE RESEARCH DIRECTIONS: THE KNOWLEDGE MARKET

The term "Knowledge Markets" is well known from literature on knowledge management. Davenport and Prusak (1998) used the term to describe the value of knowledge in modern organizations and how it was typically exchanged. Since its inception it has been embraced by a number of other authors such as (Gottchalk, 2005). Though we embrace the idea of sellers and buyers of knowledge and information we find this model insufficient and partly wrong. One of the strongest weaknesses is that their model requires that knowledge workers actively sell in their competence. In practice we have found that many will not do this. In one of the companies we worked with an enquiry exposed that 80% of the employees only used 60% of their potential on a day to day basis. But people had no active strategy for exposing this potential. In one instance a man with more than 30 years of experience in the company and a veteran from the production hall had never been involved in the department's planning or budgeting effort. Neither did he have responsibility for any personnel. When interviewed he exposed that he had been a leader of the local sports club with more than 2000 members and a budget twice the size of the department he worked in. The plant management was not aware of it before we told them.

Really what Davenport and Prusak (1998) call a market is at best an arena for insider trading and value manipulation, at the best a local fair where both vanity and politics undermine the free trade that characterizes a functional market. Ideally the currency in such a local market might be reciprocity, recognition and altruism, but all of these are strongly dependent on the monetary reward mechanisms associated with a real world economy. If basic incentives associated with bonuses, benefits and career advancing practices works against knowledge sharing and learning initiatives the currency that Davenport and Prusak describe are merely trinkets.

Our conception of the knowledge market is more influenced by the decision-market idea described by Surowiecki (2004). This is founded on the conception that crowds and statistical groups perform better than both individuals alone and deliberating groups over time. The description of "information markets" described by Sunstein (2004) has also served as an inspiration. In principle there also exist common elements between the Knowledge Market defined here and properties that characterize the adhocracy (Mintzberg, 1983), the innovative organization. That is fluidness rather than structure, socialization and congregation around common goals, competence and interest rather than historic relations and organizational authority. The most important difference is the ambition to make the Knowledge Market a permanent structure and bring the bulk of it to the virtual world. Here we have been inspired by the social successes of online games such as World of Warcraft (Böhn, 2008; Bremdal and Kirkemo, 2008; Steinkuehler, 2006). Especially the democracy of engagement and the reward mechanisms here are important to note. Current work by vendors such as CognIT (www.cognit.no) on corporate feedback and the InTouch system by Schlumberger (www.slb.com/news/

Figure 2. A depiction of the conceptual knowledge market



inside_news/2010/2010_0312_make_award.aspx) have also served as an inspiration in our conceptualization effort. The most important entries in our specification have been derived directly from the preliminary work discussed in the former paragraphs. The working concept of the Knowledge Market is depicted in Figure 2.

- The actual market place must be online
- The trading must be divided between three different markets; the Why, What and How.
- Traders must be assigned different roles with certain rights
- Trading is done in terms of nominations and extended votes
- Trading is unanimous – only the market exchange management knows who is investing
- Trading and discussion takes place in different arenas
- The Knowledge Market must be ubiquitous
- Trading incentives and career/job incentives must overlap
- All information and knowledge pertinent to trading must be transparent to all
- It should obey all principles of democracy

The Knowledge Market is a concept that embraces existing organizational elements and can well be superimposed on certain IO designs. But it will eventually cause some traditional elements to grow obsolete; others will need to be redesigned. The most important aspect is that the actual "trading floor" is online and can be a "Shared Object" for the benefit of all. This Shared Object should enjoy a central position, both in a physical space such as an IO center as well as online. It is essential to all that everything that goes on there is transparent to all. A net-based example of such a Knowledge Market is showed in Figure 3. In our research we have developed a Knowledge Market prototype where the trading of nominations is transparent to all in the organization. The example shows a selection of What-nominations and the current Idea and Problem Index.

In addition it is ubiquitous. Its omnipresence embraces the office, the video conferencing room, the workshop or the drilling deck. The vision and mission of the enterprise, together with defined management policies and such things as ethics and values define the operating rules of the knowledge market. All participants must obey by these rules. The vision and mission of the enterprise defines the ultimate purpose. But to become actionable this purpose must be translated into performing goals. We have argued that this effort is often non-salient to the point of being intuitive (Korsvold et.al, 2010). Once established they often provide the basis for a management incentive structure that tend to act counter to any forms of change when this is required. The nomination, exploration and investment in new translations as changes are recognized. An answer to the question "Why are we doing what we are doing?" defines the focus of the long term market. Consequently this arena addresses fundamental changes to the course of an operation or enterprise. It can be influenced directly or indirectly through developments in shorter term markets. Similarly tendencies in the long term market will impose reactions in the others. The definition and design of what we are going to do determine the essence of the medium term market. On a day to day basis or even more frequently, issues regarding how things should be done will be addressed. "How issues" will naturally occupy most attention due to fluctuations and incidents that constantly occur when work is performed. At this level it is important to respond quickly to the constant flow of information that is fed into the market place.

In the other markets overall tendencies and underlying structures are more important. What is important to a short term trader of knowledge in the How-market is only important to the people monitoring the What-market if these tendencies

Figure 3. A knowledge market prototype showing a selection of what-nominations including the current idea and problem index



produce a positive or negative trend of a more persistent character. The point to be made here is that a distinction should be made both in terms of information treatment as well as measures. Information pertinent to a How-trader is more like noise to the ones dealing with What and Why. Common to all arenas is that participants use whatever information they can get and their own beliefs to nominate bargains in the form of change proposals. Once posted others may invest in these or reject them.

The essence of the use of the market model to enhance collective learning is that it provides a liberal way for exchanging ideas, information, insight and experience from a diverse number of independent sources. All contributions can be made in private, in the heat of work or in the meeting room. It also favors distribution of information monitoring tasks and personal views. Basically the market place makes the Code and the contributions from the Superior Majority Group transparent to all.

There are basically two types of entries made, nominations and votes (see Figure 3). Nominations are concerns or ideas that an individual think is important. It is a simple message posted, typically at the level of a tweet. Votes are often associated with what we have called investments. The basic expression of investment serves the same function as the "Like" function that we are familiar with on Facebook. But a vote that does not commit the voter is practically useless. Consequently the contributor must make investments in a form. Evidence, information, observations or references to historic cases, references to people or literature that support or reject the proposition increases the value of the investment made. If this contribution eventually helps to support or reject a posted proposition - that is, to avoid a problem or improve a certain way of working the greater the share of the reward. This type of reward should constitute a major element in the company's incentives system. We use the term "investment" to recognize the value of the contribution and the fact that certain personal resources i.e. time, effort have been applied in order to make the contribution. The more that is invested the more likely is it that the contributions made represent a resolve or a direction, a decision basis for managers and executives. In some ways this type of trading resembles a polling system, in other ways it behaves like an auction or betting system. Traders and others may well elaborate on their beliefs in the market, their nominations and the voting, in meeting rooms or in virtual arenas. But all of this must be held separate from the trading itself to preserve the "free market" and the integrity of the individual's opinion. To preserve integrity of the market nominations and votes should be anonymous. The source of entries made in deliberating arenas, however, ought to be named.

The market is likely to pay attention to the most important and valuable bets placed. The value of the resolve or improvement eventually exploited will benefit all who traded in it. Rewards will reflect the amount of investments made and the value to the organization. It all has an appearance of a colony of ants that carefully balances exploration against exploitation of existing resources. In the latter individual ants "sell in" their discoveries. The colony has a built in recognition and aggregation function that recognizes each contribution. But only the attractive ones will be pursued. This is done as more and more individuals recognize the relative value of the good ones by maintaining a degree of self interest, collective responsibility and an inherent resource conservation mechanism. There are four fundamental prerequisites for a functional market. One is participation, another is free access to information, the other is a commitment in the form of an investment and the fourth is a reward mechanism that can easily be related to the commitment made. But to maintain a sustainable engagement participation in itself should also be rewarded. Again this should be fully embraced by the official incentive structure. Like any stock market it is essential that the value of nominations based on the net votes received becomes visual

for all who participates. This allows proponents or opponents to seek further support for their belief in order to promote or demote any value increase. This means further investments in information gathering and evidence making.

We believe it is both necessary and useful to divide traders into groups when conceptualizing. This has to do when determining the accessibility of the market. But in practice it should not be possible to distinguish entries from the one or the other group. What is important is that diversity and independence is maintained. The other is to create a balance between outsiders and insiders, that is, those who associate themselves with the organizational code and those who do not. Expert panels should be used to comment on developments and postings that are made. Yet there must be no way that the experts can manipulate the market.

Of course there is room for speculation in the market. But this is where the aggregating function comes in. The weighted mean or center of gravity of propositions is important. That is to say that, if challenged by the proposition that the cause of mud loss could be one of ten. Each of the ten is assigned a value and given a set of votes. The weighted mean would indicate with a high degree of uncertainty which cause is likely simply based on the input of a fair amount of contributors (as long as diversity and independence is secured). In other words this yields a good indicator for the decision makers to act upon. But for management the volume of trading could be even more important. The more exchanges that take place the more fluid knowledge will be and the more learning will take place. Finally the variance or the proximity of answers would be valuable. If a number of votes or investments are centered on a single nomination the risk associated with the suggested answer is low. A flatter profile would suggest increased risk due to less confidence in the evidence provided. This type of information can be applied for secondary purposes that will enable management to determine if the market is generally optimistic or not. Using other statistical techniques it is also possible to determine if the market is skewed compared to the norm. Using a family of filtering techniques that is often referred to as collaborative filtering (Johnson, 2010) it is possible to normalize the value of a contribution in accordance to historic records. This makes it possible for managers to determine also tacit elements of confidence in a proposed solution. It also helps to detect the influence and adjust for aggressive or very careful traders. As all contributions are recorded, even those nominations that will be dismissed or receive little attention will be important as it will influence the trends in a longer term perspective. Imagine that there has been a significant activity in improving efficiency in tasks related to a specific process, while other tasks related to something else have received little attention. In terms of process change this would eventually create a profile that suggests strength and weakness of how tasks have been chained together to fulfill a purpose. In turn this could spur off nominations in the arena associated with longer term investments which would trigger new nominations in this market.

How can a knowledge market like this work? First of all the operating principle is well known from different bid systems, betting and stock exchanges. The best analogy to demonstrate the viability of the concept, at least in part, beyond the financial world is the launch control center at Kennedy Space Center during the Apollo program[6]. In the pre-digital world a large number of technicians were dedicated one specific aspect of the rocket system and the launch procedure. Communication was voice based and mediated by the launch commander. Everybody could listen in and volunteer input as developments unfold. The crowd aggregated individual input through detection of congruence and conflict in real time. Decision making was largely done "open air" as real time demands required swift responses. Launching the Saturn V was a collective effort

where individual specialists pitched in, knowing that what they did would serve the collective and benefit themselves. Today it is possible to mimic this by means of modern technology. Web 2.0 technologies can support all aspects of this in the intranet and the extranet. It is important, especially for the shorter term effort, that the market is ubiquitous for as many as possible to be able to participate. Not everyone has access to the comfort of an office. Technology comparable to any smart phone will be sufficient to enable participation from groups that are more "hands-on" that others. Intelligent "aps" and hands-free systems can enable contributions in many forms i.e. images, voice, text. Equipped with a diverse set of other devices and sensors this will enable modern IT to capture meta-data and other information that is necessary to trace evidence and votes, target issues and identify contributors with a minimum of effort from the user's end. It is also our belief that the model would lend itself well to IO centers. Currently discussions (Korsvold et.al, 2010) on design have drawn references from control room design, video conferencing and office landscapes. Based on the evidence and work discussed here we think that the market analogy that we have presented here should be part of this discussion.

CONCLUSION

We have introduced the concept of Knowledge Market as a way to enhance the role of the individual within the framework of collaboration and collective learning. Our inspiration has been recent work on crowd intelligence. We have also pointed to some serious issues regarding present operations in the oil industry that needs to be addressed. We have argued that the underlying causes for these can be related to organizational unbalance with respect to drawing on internal organizational knowledge versus capitalizing on external input in order to deal with change. We also relate our arguments to cognitive weaknesses of the collective, groupthink, negative peer influence and information cascading related problems that jeopardize communication and collective learning. We elaborate on a strong body of research that supports this. Based on this we have defined a set of maxims that need to be observed to alleviate some of the problems. From this we have derived the market concept described and its most important properties. This concept could serve as a measure to be considered to enhance collaboration and collective learning, not least when preparing for a new future in the industry based on integrated operations. At the present time the Knowledge Market model offers qualities of collaboration that yields some clear learning advantages both on an operational level and in terms of strategy change.

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REFERENCES

Apache. (2011). *Web server.* Retrieved from http://httpd.apache.org/

Baron, R. (2005). So right it's wrong: Groupthink and the ubiquitous nature of polarized group decision making. *Advances in Experimental Social Psychology*, *37*, 219–253. doi:10.1016/S0065-2601(05)37004-3

Barsa, M., & Dana, D. A. (2011). Reconceptualizing NEPA to avoid the next preventable disaster. *Boston College Environmental Affairs Law Review, 38*(2). Retrieved from hhtp://lawdigitalcommons.bc.edu/ealr/vol38/iss2/2

Böhn, K. (2008). *KnowledgeCraft proposal preparation*. Workshop FHG AIAIS, Bonn, 31.1.2008

Bremdal, B. A. (2001). The HBS method. In *Norwegian: HBS metodikken. Basert på FAROS Metodebok for HAMP Business System) v1.1 juni 2001*. Hydro Aluminium.

Bremdal, B. A., & Kirkemo, K. (2008) *The KnowledgeCraft project - EU R&D proposal.* ST-FH C1011, Statoil June 23, 2008

Bremdal, B. A., & Korsvold, T. (2009). *Why, what and how charts: Towards a method for analyzing and designing tools, arenas and organizations for improved collective intelligence*. Narvik University College Report, (revised version 2011).

Bretton Woods Project. (2011). *Groupthink: IMF slammed for mistakes before crisis*. Bretton Wood Update, No 74, Jan-Feb. Retrieved from http://www.brettonwoodsproject.org/art-567577

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston, MA: Harvard Business School Press.

Davis, G. (1998). *Creating scenarios for your company's future*. Paper presented at The Conference on Corporate Environmental. Health and Safety Excellence, New York City – 28 April 1998

Encyclopedia.com. (2011). Peer influence. In *International encyclopedia of marriage and family*.

Gottschalk, P. (2005). *Strategic knowledge management technology*. Hershey, PA: Idea Group.

Haavik, T. (2010). Chasing shared understanding in drilling operations. *Cognition Technology and Work*, *13*(4). Retrieved from http://www.springerlink.com/content/n0l6823328713x35/

Haavik, T. (2010a). Making drilling operations visible: The role of articulation work for organisational safety. *Cognition Technology and Work*, *12*(4), 285–295. doi:10.1007/s10111-010-0139-2

Haavik, T. (2011). Challenging controversies: A prospective analysis of the influence of new technologies on the safety of offshore drilling operations. *Journal of Contingencies and Crisis Management*, *19*(3).

Hansen, C. D., & Johnson, C. R. (Eds.). (2005). *The visualization handbook*. Amsterdam, The Netherlands: Elsevier-Butterworth Heinemann.

Holland, J. H. (1975). *Adaptation in natural and artificial systems*. Ann Arbor, MI: University of Michigan Press.

Holland, J. H. (1995). *Hidden order - How adaptation builds complexity*. Reading, MA: Addison Wesley.

Howe, J. (2008). *Crowdsourcing: Why the power of the crowd is driving the future of business*. New York, NY: Crown Business.

Janis, I. L. (1972). *Victims of groupthink: A psychological study of foreign-policy decisions and fiascoes*. Atlanta, GA: Houghton Mifflin.

Janis, I. L., & Mann, L. (1977). *Decision making: A psychological analysis of conflict, choice, and commitment*. New York, NY: The Free Press.

Johnson, P. E. (1983). What kind of expert should a system be? *The Journal of Medicine and Philosophy*, *8*(1), 77–97.

Johnson, P. J. (2010). Python for collective intelligence and collaborative filtering. *The Python Papers Monograph 2:8, Proceedings of PyCon Asia-Pacific 2010*.

Johnson, P. M. (2001). *Effects of groupthink on tactical decision-making*. School of Advanced Military Studies, United States Army Command and General Staff College, Fort Leavenworth, Kansas, First Term AY 00-01. Monograph.

Korsvold, T., Haavik, T., Johnsen, S. O., Danielsen, J. E., Herbert, M., Rommetveit, R., & Bremdal, B. A. (2009). *Creating resilient drilling operations through collective learning.* Paper SPE 124039 presented at SPE Asia Pacific Health, Safety, Security, and Environment Conference and Exhibition held in Jakarta, Indonesia, 4–6 August 2009. Retrieved from http://www.onepetro.org/mslib/app/Preview.do?paperNumber=SPE-124039-MS&societyCode=SPE

Korsvold, T., Madsen, B. E., Bremdal, B., Herbert, M., Nystad, E., & Danielsen, J. E. (2010). *Creating an intelligent energy organization through collective learning*. Paper presented at SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Letnes, B., & Korsvold, T. (2008). *Managing change with the integrated drilling simulator*. F6518/ 36.6417.00/03/08 SINTEF Report

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71–87. doi:10.1287/orsc.2.1.71

Mintzberg, H. (1993). *Structures in fives: Designing effective organizations*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Moltu, B., & Nærheim, J. (2010). IO design gives high efficiency. *SPE Economics & Management*, *2*(1), 32–37. doi:10.2118/126534-PA

NASA. (2008). *Columbia crew survival report.* NASA/SP-2008-565 Report.

Newell, A. (1982). The knowledge level. *Artificial Intelligence Magazine*, *18*(1), 87–127.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. New York, NY: Oxford University Press.

O'Reilly, T., & Battelle, J. (2009). *Web squared: Web 2.0 five years on*. Position paper for the Web 2.0 summit.

Paulus, P. B., & Van der Zee, K. (2004). Should there be a romance between teams and groups? *Journal of Occupational and Organizational Psychology*, *77*, 475–480. doi:10.1348/0963179042596496

Ringstad, H. E., Ødegård, T., Tidemann, A., Einarsen, L. A., & Thomsen, T. (2008). *The team compass: Team building with type understanding,* In Norwegian. Bergen, Norway: Optimas. Retrieved from http://www.optimas.no/team.htm

Rosenthal, U., & Hart, P. (1991). Experts and decision makers in crisis situation. *Knowledge: Creation, Diffusion*. *Utilization*, *12*(4), 350–372.

Rosness, R. (2001). *Lean and vulnerable? About the value of organizational redundancy.* (In Norwegian) SINTEF Report STF38 A01413, Trondheim.

Schumpeter, J. (1934). *The theory of economic development*. Cambridge, MA: Harvard University Press.

Scott Armstrong, J. (1980). The seer-sucker theory: the value of experts in forecasting. *Technology Review*, *82*(7), 16–24. Retrieved from http://works.bepress.com/j_scott_armstrong/1

Senge, P. M. (1990). *The fifth discipline: The art & practices of the learning organisation*. Doubleday.

Shanteau, J. (2001). What does it mean when experts disagree? In Salas, E., & Klein, G. (Eds.), *Linking expertise and naturalistic decision making*. Mahwah, NJ: Lawrence Erlbaum Associates.

Shuen, A. (2008). *Web 2.0: A strategy guide*. O'Reilly.

Steffensen, J., & Bremdal, B. A. (2006) *In what way does corporate knowledge hold the key to future success?* White Paper on Hydro Aluminimums Business, Vækerø, Oslo 2006.

Steinkuehler, C. A. (2004). Learning in massively multiplayer online games. *Proceedings of the 6th International Conference on Learning Sciences*, (pp. 521-528).

Strickland, L. H. (1958). Surveillance and trust. *Journal of Personality*, *26*(2), 200–215. doi:10.1111/j.1467-6494.1958.tb01580.x

Sunstein, C. R. (2004). *Group judgments: Deliberation, statistical means, and information markets*. U. Chicago John M. Olin Law & Economics Working Paper No. 219 (2nd Series). Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=578301

Surowiecki, J. (2004). *The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business, economies, societies and nations*. London, UK: Little Brown Book.

Sutton, R. (1996). Generalization in reinforcement learning: Successful examples using sparse coarse coding. *Advances in Neural Information Processing Systems*, *8*, 1038–1044.

Tinmannsvik, R. K., Albrechtsen, E., Bråtveit, M., Carlsen, I. M., Fylling, I., Hauge, S., et al. (2011). *Deepwater Horizon-ulykken: Årsaker, lærepunkter og forbedringstiltak for norsk sokkel.* SINTEF report A19148.

Voydanoff, P., & Donnelly, B. W. (1999). Multiple roles and psychological distress: The intersection of the paid worker, spouse, and parent roles with the role of the adult child. *Journal of Marriage and the Family*, *61*(3), 725–738. doi:10.2307/353573

West, M. A., & Slater, J. A. (1995). *Teamwork: Myths, realities and research*. Occupational Psychology, Institute of Work Psychology, University of Sheffield, April 1995, 24-29

ENDNOTES

1 E.g. drilling teams, subsurface team, well intervention team onshore and offshore.

2 The principle is also well illustrated in practice by robots applying a variety of machine learning algorithms such as reinforcement learning (Sutton 1996) and ant colony optimization where robots learn to operate by themselves through a mix between exploitation and exploration.

3 And partly also in terms of strength where strength relates to authority, influence of individuals and engagement. However, the original model addresses only the likelihood of code change as a function of the number of people that shares the superior majority beliefs.

4 Statoil's A-team and A-standard initiative is a case in point

5 A few relationships can be very strong and to some degree affectionate while others are more casual, but still socially important.

7 To develop a notion of how the launch was performed there are some interesting historical material posted on YouTube: http://www.youtube.com/watch?v=n2mjvNvj5yM&feature=related

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Chapter 19
The Terms of Interaction and Concurrent Learning in the Definition of Integrated Operations

Trygve J. Steiro
Norwegian University of Science and Technology (NTNU), Institute for Production and Quality Engineering, Norway & SINTEF Technology and Society, Norway

Glenn- Egil Torgersen
Norwegian Defence University College, Norway & Institute for Energy Technology, Norway

ABSTRACT

This chapter introduces a new definition of Integrated Operations (IO) adapted to the oil industry. This definition focuses on interaction. Such an approach is necessary to emphasize learning processes in the organization's various echelons. It is an important assumption for the success of IO as a flexible and complex organization. The term "Interaction" is elaborated with special emphasis on "Concurrent Learning." Such an approach ensure reflection during the process leading up - the way forward - to the target and the development of a more fundamental organizational philosophy rather than just focusing on the result. It will create a more robust "integration" between technology, people, and organizations so that a higher capability in integrated operations can be achieved.

INTRODUCTION

Over the past decades, various disciplines, such as quality management, performance measurement, process management, IT processes and a variety of tools focused on improving business processes. The angle normally has been that the processes are repetitive activities that give best performance by standardizing and streamlining. The result is a range of methods and tools geared towards this. Process models, performance indicators, quality assurance, IT support, all aim to describe and support these processes. The "predictable" and repetitive processes do this well, huge efficiency gains are achieved in mass production processes and standardized procedures.

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This approach, however, also has its limitations. In many sectors, all or part of the processes are less standardized and rather more dynamic, such as customer custom products that require slightly different manufacturing processes, course of treatment in the health sector where the process will vary depending on the blood samples and other information collected along the way, customer service depends heavily on customer needs that are discovered en route. For such processes requires a different approach, which allows such dynamic processes to be led through continuous improvisation, on-line problem solving and interaction with actors and processes. This will typically be a fast growing environment where the tasks are not standardized. In such condition, flexible forms of organization are recommended. This was pinpointed by Burns and Stalker (1961).

The petroleum industry is undergoing a transition made possible by new and powerful information technology. Traditional work processes and organizational structures are challenged by more efficient and integrated approaches to offshore operations. The new approaches are taken into use to overcome traditional obstacles – whether they are geographical, organizational or professional – to efficient decision making (Ringstad & Andersen, 2006). This way of working together is in the petroleum industry referred to as *Integrated Operations (IO)*. This is an example of a decentralized and organic organization (see Table 1).

IO intends to enhance the experience of integration and common understanding between the onshore and offshore organizations. This may result in faster and better decisions, because both the onshore and the offshore personnel have in-depth knowledge about the situations and challenges that arise. Several companies on the Norwegian continental shelf have implemented IO as a strategic tool to achieve safe, reliable and efficient operations. The IO collaboration technology consists of high-quality video conferencing, shared work spaces and data sharing facilities. These arenas include so-called collaboration rooms (operation rooms) for rapid responses and decision-making. The design includes video walls to share information and involve people in discussions with each other both onshore and offshore.

The introduction of IO implies that the tasks involved in petroleum production are redefined and reorganized, and many tasks are relocated (typically from offshore to onshore). In addition, a range of new information and communication technology (ICT) systems, such as decision support systems and collaboration technologies, is being introduced. This impacts the work practices applied within the industry. Ringstad and Andersen (2006) present a vision of how IO will change the ways of working in petroleum companies (Table 2).

Such efforts require a facet of expertise and flexible management, logistics, training and

Table 1. Organizational form due to four field matrix, simple or complex tasks and stable or dynamic environment based on Mintzbergs (1983) taxonomy

	STABLE ENVIRONMENT	**DYNAMIC ENVIRONMENT**
Complex organizational architecture	Decentralized bureaucracy Professional bureaucracy	Decentralized-organic Ad-hocrati
Simple organizational architecture	Centralized bureaucracy Machine bureaucracy	Centralized-organic Simple structure

Table 2. IO and new ways of working in petroleum companies (Ringstad & Andersen, 2006)

Traditional way of working	**Integrated Operations way of working**
Serial	Parallel
Single discipline	Multi discipline
Dependence of physical location	Independence of physical location
Decisions made based in historical data	Decisions are made based on real-time data
Reactive	**Proactive**

evaluation systems. In order to grasp and express this resource and strategy conglomerate may the collective term "capability" be appropriate. Henderson et al. (2012) argue that the capability could embed performances and learning in order to improve integrated operations. This can be seen as response to the limitation of a stable market and traditional hierarchies represents in a dynamic market a flexible approach to organizing should be strived for (Burns & Stalker, 1961). Dynamic capabilities can be defined as; *"The firm´s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (*Teece et al., 1997: 516). Leonard- Barton (1992) writes that dynamic capabilities reflect an organization´s ability to achieve new and innovative forms in order to gain a competitive advantage. Teece et al. (1997) argue further that capability could emphasize the interaction between people, process, technology and governance. This is assumed to be a more dynamic approach in order to understand improvements. Teece and Pisano (1994) define dynamic innovation ability as a subset of competence and ability that enables new product and processes as responses to changes in market condition. The ability to integrate and make use of knowledge can be essential for an organization and is often termed as core competence (Prahalad & Hamel, 1990). Hamel and Prahalad (1994) define core competence as collective learning. The collective learning is related to how different competences and technologies are coordinated and integrated. One of the challenges with some of the capability theory (i.e. Teece et al., 1997) as we see it, is that the theory focuses on change with defined factors, and to a lesser degree mastery of the unexpected. Another way of defining capability is:

...the ability of an organization to achieve the goals that have been set for it. Capability refers to the degree to which the organization is structured to ensure achievement of the goals: the extent to which the culture is appropriate for the achievement, the degree to which there are the right sorts of people with the right attitudes and skills and attributes in the right number, motivated, rewarded, equipped, trained and managed to do the right sorts of things into the right sorts of ways. (Salaman and Asch, 2003: 27).

Hepsø (2006) claims that the early work on integrated operations was focused mainly on technology, treating human and organizational issues as the remaining factor or on the opposite view, was all about people and processing and nothing about technology. Now, business process thinking has become the cornerstone of integrated operations (Henderson, et al., 2012). We want to strengthen the focus on human factors, competence, learning and the way people interact with each other and with the technology. Our contribution in this chapter will be focusing not on the strategic level in the organization but focusing more on the sharp end. In order to build more capability into intergrated operations, we will argue that interaction and learning in Integrated Operations could be a fruitful way forward.

TOWARDS A NEW DEFINITION OF INTEGRATED OPERATIONS

There are several different approaches and definitions of "Integrated Operations," for example Ringstad and Andersen (2007:1) defined IO as *" ...new work processes which use real time data to improve the collaboration between disciplines, organizations, companies and locations to achieve safety, better and faster decisions.."* The Norwegian Ministry of Petroleum and Energy states that IO implies: *"...use of information technology to change work processes to achieve improved decisions, to remotely control equipment and processes, and to relocate functions and personnel onshore."* (sec.ref. Skjerve et al., 2008:5). Grøtan et al. (2010:1) claim that *"Integrated Operations*

(IO) is not a term that is possible to define in a strict sense…," and they gently warn that the construct *"… carries a lot of "fluid" meaning that encompasses a diversity of needs and agendas, not least because that currently it aims at how future operations will look like."* (ibid.).

CERA define integrated operations as: *"The vision of the Digital Oil Field is one where operators, partners, and service companies seek to take advantage of improved data and knowledge management, enhanced analytical tools, real-time systems, and more efficient business processes."* According to Edwards et al. (2010), this is the most commonly used definition in 2010. As can be seen from all these definitions, the emphasis is put on technology and the development has primarily been technology driven.

However, the definitions and different descriptions and approaches have unilateral focus on organizational structure as such and perceived benefits of interaction between land and sea, including the use of new technology. In our view it is surprising that the expression of learning, motivation and didactic leadership and strategies are seldom or never included in the definitions, associated amplifications and IO-reports. In our opinion, these interpersonal processes are essential to obtain the benefits that are planned with the concept of IO. It is also clear that IO involves new ways of thinking and conduct of management and leadership, since communication, guidance and training of different levels and functions, will largely take place digitally. This "phantom" structure of leadership, collaboration (interaction) and logistics of material and immaterial substance, will clearly imply a reinforced emphasis on education and training in new ways for all employees and partners, both as organized courses and while the work is in progress (Torgersen & Skjerve, 2012).

One such way to go is used in the development of "Network Centric Warfare" in the armed Forces, which in our opinion has many features in common with IO. Furthermore, the petroleum industry has probably taken the concept of "Integrated Operations" from the defense terminology, cf. also "Joint Operations" and "Combined Operations," which covers just cooperation or interaction between different military capacities, where the communication between levels and functions is digital, partly based on remote control (Downie, 2005). Central to these concepts is to develop people, organization and technology. The goal is most effectively to organize the resources in the integration, both within and between the parts that make up the whole, including the organizations or manager's intent and objective. In this way, in principle, all integral parts or actors be included in any work process and as a basis for situational awareness, risk assessment and decisions (Alberts et al., 1999). In military operations, it will also be necessary to change and restructure these large resources quickly, which requires flexibility. This cannot happen effectively without putting a person at the center, with extensive and ongoing training and especially the systematic use of experiential learning, (cf. "After Action Report," Torgersen, 2008). Not least, this is necessary to identify what skills should be trained. In other words, this understanding clarifies the integration of learning, organization, management, technology and work processes at all levels of the system - even with the network and partners outside the organization. Based on what we assume, this is also an approach that should be relevant to the "Integrated Operations" in the oil industry.

Effective IO over time requires a coherent link between the different didactic phases, from the basic philosophical and strategic view in the organization; the IO mindset; and the understanding of interaction, and to the pointed end - which in this context is the actual and concrete relevant teaching and training, the individually adapted learning material and the competence development for each employee (cf. Skjerve & Torgersen, 2007). For the individual this will provide the basis to mastering the daily work tasks in an IO-oriented organization.

As a contribution to the development of IO in the petroleum industry, we introduce the following definition of IO:

Integrated Operations (IO) is an organizational form in the petroleum industry that facilitates the interaction between organization, leadership, technology and work processes at all levels and functions, between land, sea and partners, to develop resources and logistical chains adapted to the organization's intention.

Learning and flexibility as well as underlying interpersonal processes such as *trust*, is included in this concept of interaction. Such a definition will therefore require a clearer focus on leadership and facilitation of education and training at all levels in the oil industry. Such an approach will ensure reflection during the process leading up, or the way forward, to the target. It will also ensure the development of a more fundamental organizational philosophy rather than just focusing on the result. It will create a more robust integration within and between the different parts and participants involved in the organization's activities and actions or "operations." However, since we have introduced the construct *interaction* in the definition of IO, we will further elaborate this concept further, and in particular involve *flexibility* and a specific learning process, namely "Concurrent Learning."

FLEXIBILITY AS A TERM

In the book *"Building the Flexible Firm: How to Remain Competitive"* (1999), Henk Volberda points out that flexibility has a positive connotation associated with it and believe that we should question whether flexibility is used as a magic word, or if this is a new short-lived fad in management. It is worth noting that a recently published Norwegian book which deals with flexible organizations, points to that flexible organizational form is not a unitary concept. Opinion content varies and covers a wide range of different organizational solutions and working methods (Assmann & Hillestad 2008). Assmann and Hillestad (2008) concentrate on project organization, matrix organization and team organization, but do not elaborate on the concept of flexibility. Intuitively, we think of flexibility as dynamic, responsive or a capacity for adjustment. Toffler (1985) relates the concept of flexibility to adaptability. Ansoff (1979) relates the concept to the preparation and writes that it is a prerequisite for survival. Other definitions are:

Flexibility can be considered as a new way to achieve some form of control in extremely turbulent environments (Volberda, 1999:89).

Flexibility means an ability to adapt aspects of the organization rapidly in the face of new opportunities and threats in the environment (Birkinshaw, 2000:5).

Flexibility is necessary for innovation, but not alone sufficient to create it (Volberda 1999). Burns and Stalker (1961) and Woodward (1965) argued that there was no guarantee that companies would find it a necessary or sufficient organizational model for managing the environment in a flexible manner. To be successful with the adaptation depends on senior management interpret and indicates the conditions they face in an appropriate manner and take appropriate measures.

INTERACTION TERM AND UNDERLYING PROCESSES

Interaction is often used synonymously with traditional notions of "collaboration," "interaction," "coordination," and "cooperation." Different terms can cover the same processes, and we can get the impression that the saying "the emperor's new clothes" makes it felt. Conceptual change in itself of course does not automatically give some efficiency benefits.

The term interaction is used by many of the agencies, companies, researchers and textbook authors, without clarifying the rationale for the use of it (Torgersen & Steiro, 2009). It is always difficult to achieve a common understanding of concepts covering complex phenomena and processes. Therefore it is important to clarify what is meant by the concepts one wishes to use. If this is done, it will be easier to identify underlying factors and assumptions in the processes that the term should cover, do something with them, and streamline processes in order for products to be improved. We will eventually still see that there are several overlapping and complex meanings of these concepts.

Since interaction has become a "modern" and contemporary concept, it is therefore a risk that the concept can be used with a sales motive rather than a deliberate scientific justification. However, the use of the term may also be related to the "new" conditions, such as technology, new organizational structure and division of labor. These are linked to traditional processes such as "team," "cooperation" and "coordination." Overall, this is perceived as different from how "cooperation" and "coordination" is understood by most people. There is a need to choose other terms to cover this, despite any differences that are clearly identified or articulated. Furthermore, emphasis on different underlying processes, such as the degree of involvement, degree of exchange of expertise or the meaning of trust, serve as a basis for different concepts.

DECONSTRUCTION OF THE INTERACTION TERM

The concept of "Samhandling" (in the Norwegian language) has no equivalent in the English language. The direct translation of "samhandling" is "interaction." Although this word does not cover the interaction precisely, it is still better than the words and expressions that might otherwise be used for collaboration and group processes, such as teamwork, co-operation "or" collaboration "even " join forces with ... ." For these there are many definitions, and they are relatively similar in terms of common knowledge, the focus that some work together. For example, a definition of "collaboration":

The collective work of two or more individuals where the work is undertaken with a sense of shared purpose and direction that is attentive, responsive, and adaptive to the environment (Beyerlin & Harris, 2004:18, sec. ref. Nemiro et al., 2008:1).

In this definition is the act and the situation is not as prominent as it relies on the interaction. In such classic definitions, the focus is "collective," i.e. to do something together (teamwork), either simultaneously or in part along an assembly line, each contributing to the whole, each with his own specialty. In other words, a kind of collective "lift." Based on several definitions of the team we have chosen Assmann`s (2008) following definition of team:

Team is a small, multidisciplinary group composed for a common purpose and the members feel a common responsibility to ensure that they achieve results. (ibid.:37).

Levin and Rolfsen (2004:69) have a similar definition, but focus more strongly on the relationships between team members:

A team consists of at least two people who have face-to-face relationships, it must exist over a certain period of time, establishing emotional connections between members, they must have a common purpose and understanding of performance requirements, and must meet specific criteria for membership.

These definitions describe in principle a form of organization, not the process or work, but nevertheless suggest a process carried out by the ”team” where the collective and joint are central. The unique contributions of each individual, each complementing the other in a holistic process, an interactive development process, where the players not only help with their competence, but they also develop and learn from each other during the process. Technology or equipment is crucial in many complex tasks. This is the interaction term as we see it, and it therefore describes something qualitatively different from the concept of cooperation of collaboration.

Definition of Interaction

Based on the synthesis, which we extract from the aforementioned examples in Table 1, we have developed this definition of interaction:

Interaction is an open and mutual communication and development between actors in terms of expertise complements each other and develop skills, direct face-to-face or mediated by technology or by hand, working towards common goals. The relationship between players at any given time rests on trust, involvement, rationality and industry knowledge. (Torgersen & Steiro, 2009:130).

Based on the definition we see that interaction is not only a process that is reserved for management and leadership, but also takes place in the production and common labor processes in which people work together. Interaction is primarily a way to work or ”act” on. Central to the interaction is in fact ”action,” first and foremost a targeted action. The action is shared or exchanged expertise - often extensive and specialized and used complementary. There is reason to use the concept of action linked to the skills needed to participate in an interaction process. It is important that people feel they are included and definitely not feel rejected. Johannesen and Rosendahl (2010) express something similar:

If we take the assumption that social rejection is one of the fundamental pillars of human interaction, the interaction skills essential to prevent some people feel socially rejected. Respect, responsibility and dignity of others is thus, as we see it, the ethical side of the inter-action skills. To disarm the interaction capabilities of the ethical element is the same as to make blind people to machines. (Johannessen & Rosendahl, 2010:85, our translation).

Furthermore, interactions depend on both individual characteristics and skills, structural and cultural components and the awareness that such expertise is a necessity for interaction. To get it, it would be advantageous if the players knew each other’s ways of thinking at least as well as possible (Moldjord et al., 2010). If the participants actively contribute with their expertise into the community, not least actively listen to each other and in turn are conscious of this necessity. This confirms the importance of involvement and awareness in working together and being sensitive to each other so that interaction can be achieved.

Interaction as a “Way Forward”

One must also be aware that each participant contributes with her unique situational understanding (”shared situational awareness”), based partly on their own perspective and position in the organization, experience, culture, knowledge, attitudes, emotions and job satisfaction including recommendations to the interaction process (Sandeland & Boudens, 2000). In other words, while traditional collaborative and cooperative processes in principle are subject to collective actions in occupied common vision and understanding, it is in its nature that interaction requires different situational understanding. It is further the process forward, or ”way forward” to a common understanding or use of the various competencies, such a tool to solve a problem, a product, goal, which is unique in an interaction process. Interaction therefore includes an aware-

ness of relationships and the actors' interaction or exchange. We believe the word "reciprocity" could otherwise be confused with influence, control or uniformity. What mainly separates interaction from the collaboration/ teamwork/ cooperation, in other words, an extra emphasis on hands on the complementary side, i.e. adaptation, and exchange and the exploitation of the participants' different skills, experience and background or culture and channeling it into the work towards a common goal during the work or meeting process. Common understanding is built and developed.

Concurrent Learning in Interaction (CLI)

A *Concurrent Learning process* means that the participants learn from each other during the interaction process. In the same the team players on the football field get to know each other's specialties to be able to best facilitate each other in order to be used as a joint force. Furthermore, the Concurrent Learning concept does not only involve being familiar with competence, one must also learn a little so an individual can connect this to their own competence, and thus develop their own unique expertise together with the others. In this way, the complementary expertise really becomes an active skill that can be put to the task. This learning process will take time, and must take time, and the process must be deliberate and organized. It means that leaders and participants should plan for this in an interaction process. It must be included in the training to develop interaction skills, and it must be included in the strategic plans of the organization. In light of the interaction, we define the term Concurrent Learning as follows:

A deliberate and continuously functional and interacting learning process among actors that occurs simultaneously with the interaction.

This kind of learning process is not *incidental*, but *intentional* or purposeful, in the sense that the players need to be aware of this process, and need to focus on the relationship between one´s own and the others expertise and diversity. Concurrent Learning is also a *functional* process in the sense that learning also occurs through daily interaction activities or actions. Concurrent Learning and interaction are co-dependent on each other, and they are therefore in a way the same process (therefore CLI), and assume among other things trust and balance in power between the actors and the other indicators for effective interaction.

What is Effective Interaction?

One can say that "effective" interaction involves exploiting the participant´s combined expertise as much as possible, so that they complement each other during the meeting (or work process), and channel it into the common goals and understanding, which can contribute to better solutions and decisions. This does not happen by itself, cannot be ordered, but must be the result of active involvement of participants themselves. In such involvement, awareness is therefore essential for effective interaction. Such interaction processes must be directed on the participants' own terms, while the leader must be prepared to enter and emphasize their role if necessary (Hansen, 2009). This can happen if simultaneous situations occur, for example, if some participants lose focus or involvement in the mission objective, or technology malfunctions. The manager's task is then to capture the participants' attention and direct this into the tasks, and not appear to be an authoritarian. In other words, an interaction manager develops an eye interpreting the interaction process and the progress of this. This means that the leader must be aware of the many assumptions required in order to make the interaction optimal. It is also important that the participants develop a sense for her to ensure her contribution for the good of interactions. Therefore, interaction assumptions

form an essential awareness both prior to and during the interaction processes, such as training and reflection.

15 Indicators of Interaction

We have in Table 3, listed a number of underlying processes that are crucial for effective interaction to take place. This of course does not mean that the indicators can be viewed as universal to all organizations and businesses. Each organization must choose to develop the conditions that are the most meaningful for their business. However, the list may still be a good starting point for such development.

We believe that interaction, with the points mentioned in the table and a greater focus on activities and how they performed in concert make that interaction into something that goes deeper and wider than cooperation. However, it is not the case that these conditions constitute a direct cause-effect relationship in the phenomenon of interaction, but in our opinion key assumptions and characteristics. In other words, the organization should consider these factors in the development of interaction processes in the organization. It is these underlying processes that should be made aware and trained so that they can be a natural part of the daily interaction processes. Such a learning process should be done both through formal training and concurrent learning.

Table 3. Key underlying processes that are important for effective interaction based on experiences from a variety of businesses and theoretical approaches (Torgersen & Steiro, 2009:157f)

Underlying process	Explanation
Coordination	Distribution of duties, transfer duties to the right place and with the right competence
Complementary expertise	Complement each other with their unique expertise
The Ethical aspect	Assume that all participants have equal value and dignity, have respect for each other and are willing to take responsibility in the interaction process
Learning	Mutual learning from each other in the interaction processes
Interaction Training	Practice the above-mentioned conditions, that are important for the interaction terms
Involvement and awareness	Be willing to, and aware of the need to contribute actively
Mastering Tool	Be able to master various tools that are part of interactions (technology, tools and other materials) in a professional and educational way
Organizational and cultural knowledge	Awareness about the organizational structure and culture that are in the organization, be aware of "what is"
Power balance	Absence of dominance/power balance between participants, conscious that the power structures and the experience of this may be something different in an interaction process than in traditional teams and cooperation
Precision communications	Express themselves clearly, the knowledge and use of presentation skills
Role awareness	Knowing each other's roles, functions and work distribution in interactions
Professional logic	Developing a common understanding of the language and industry jargon. This may have evolved in the organizations that is not necessarily universal and objective, but is current and valid only within the organization. The participants must be aware of the jargon to enable good communication to establish a foundation for interaction
Sense	Development of a kind of accurate understanding of the growth during an interaction process, and what should be done
Shared situational awareness	Be conscious of their own understanding, and contribute to this in the process, where mutual understanding and focus gathered during the interaction process
Trust, transparency and confidence	Experience confidence, trust each other and be able to give of themselves

Military organizations, for instance, manage large procurement projects such as complex purchases of military aircraft including long- term maintenance contracts that place high demands on both the military as the customer and on the supplier or network of suppliers. The technological and logistical challenges involved are significant. In order to ensure that the parties cooperate as efficiently as possible, to help guarantee the reliability of deliveries for, and availability of, something like a fighter jet, we will argue that there is much to be gained by focusing on organizational and interpersonal aspects, as well as by teaching and training people to be aware of fundamental communication processes. These "soft" questions can in turn often become sidelined, so it is important to understand the issues at stake (Torgersen & Steiro, 2010). In the next part we will introduce an example on how these issues can be approached.

THE DEVELOPMENT OF INTERACTION SKILLS: A CASE STUDY IN INTEGRATED OPERATIONS USING THE SOFIO-METHOD

The method "Structured Observation and Feedback in Integrated Operations" (SOFIO, see Kaarstad et al., 2009) was developed in order to identify successful IO collaboration techniques, and to continuously improve a team's interaction skills in an IO setting. The method is based on fundamental methodological principles for assessing virtual team effectiveness (i.e. Lurey & Raisingham, 2001), and is a development of the power factors "Group," "Task," "Context," and "Technology" (ibid.). The SOFIO approach is, to our best knowledge, unique to the extent that a large quantity of sharp meetings and collaboration sessions (in total 28) were observed over time (3 months) from a third party video laboratory (Kaarstad et al., 2009). SOFIO is based on recognising collaboration as key to organisational efficiency, featuring:

- Training and coaching in a real work situation
- Remote observations with immediate feedback from a broadly composed interdisciplinary expert team
- Practical and holistic view on collaboration skills pertaining to teamwork, technology, communication and IO process compliance

SOFIO has a strong focus on enabling the team or organization to continue self-training and learning in everyday operations. During the series of observations in one oil and gas organization, clear improvements in the participants' interaction skills were reported (Kaarstad et al., 2009). Based on this work, successful interaction and interaction skills in an IO setting can be summarised in the following general recommendations (ibid.:7):

- Be conscious of what you understand by interaction
- Deploy yourself as a tool for clear communication
- Make use of each other's competence
- Technology shall support and enable a desired work practice, and not the other way around
- Understand the work process and put it to good use
- Train as you work

FUTURE RESEARCH DIRECTIONS

We will argue that a strong theoretical focus on IO is necessary. We have made some suggestions in this article but on the same time recognize that more work need to be carried out. It is also important to align the theoretical to the practical

implications of integrated operations in order to achieve a positive outcome. In this article some examples are given, but more work need to be done to fully understand the implications of interaction and concurrent learning. Similar to the paper of Edwards et al. (2010) we also see the cultural dimension as important and it is important to address these issues in a company making sure that the concepts are fully understood but also developed in a fashion that suits the company and not only are copied as a nice to have feature. The core point in working with organizations lies to our opinions, not so much in the formulation of strategy but more in the realization of the strategy. A further study of interaction and concurrent learning will provide more valuable insight into the domain and answer some questions and at the same time raise new questions of importance. More knowledge should be gained from studying sharp end operations and see them in relation to perspectives on capabilities.

CONCLUSION

We have argued that complementary competence and Concurrent Learning are two key aspects of the interaction. These two will thus be an aid or tool for flexibility and build capabilities, and secondly the development of flexible organizations. This is because flexible organizations are constantly in need of structural change and different and complementary expertise to solve new tasks.

The Integrated Operation based interaction technology, is not just mosaic oriented with for instance larger meetings between onshore and offshore. It will be necessary with dialectic systems where communication take place more frequently and with fewer people involved. It is necessary with visual contact with the support of documentation (equivalent to Skype technology). In order to streamline interaction and distributing decisions, training is important not only training on technology, but also on communication for the communication to be accurate and clear.

To raise awareness and clarify and systematize complementary competence, it is necessary that the players learn from each other during the interaction activities. Interaction therefore represents a *mindset, way of work and form of learning*, which together are helping to meet or develop the skills needed to cope with the challenges of flexible organizations. Arrangements and the development of training and management of the exploitation of complementary competence and Concurrent Learning, are therefore important strategic measures for efficient development of flexible characteristics for the organization.

We believe that an important prerequisite for success in today's society, with frequent and complex changes, is not just to focus on technology, but likewise focus on the development of human values and knowledge. More knowledge about the practical implications of interaction is needed. One such concept is IO, and we think that the concept of interaction and Concurrent Learning are something to explore further.

REFERENCES

Alberts, D. S., Garstka, J. J., & Stein, F. P. (1999). *Network centric warfare: Developing and leveraging information superiority*, 2nd ed. Washington, DC: CCCR Publication series, National Defence University.

Ansoff, I. (1979). *Strategic management*. London, UK: MacMillan.

Assmann, R. (2008). Team og teamorganisering. [Team and team organization] In Assmann, R., & Hillestad, T. (Eds.), *Teamorganisering. Veien til mer fleksible organisasjonsformer* [Team organization. The way a head for more flexible forms of organization]. Bergen, Norway: Fagbokforlaget.

Assmann, R., & Hillestad, T. (2008). Forutsetninger og betingelser. [Conditions] In Assmann, R. (Ed.), *Teamorganisering. Veien til mer fleksible organisasjonsformer* [Team organization. The way a head for more flexible forms of organization]. Bergen, Norway: Fagbokforlaget.

Beyerlin, M., & Harris, C. (2004). *Guiding the journey to collaborative work systems: A strategic design workbook*. San Francisco, CA: Jossey-Bass/ Pfeiffer.

Birkinshaw, J. (2000). Network relationships inside and outside the firm, and the development of capabilities. In *J. Birkinshaw & P. Hagström (2000). The flexible firm: Capability management in network organizations*. Oxford, UK: Oxford University Press.

Burns, T., & Stalker, G. M. (1961). *The management of innovation*. London, UK: Tavistock.

Downie, R. D. (2005). Defining integrated operations. *Joint Force Quarterly*, *28*, 10–13.

Edwards, T., Mydland, Ø., & Henriquez, A. (2010). *The art of intelligent energy (iE)- Insights and lessons learned from the application of iE.* SPE 128669, Paper presented at the SPE

Grøtan, T. O., Albrechtsen, E., Rosness, R., & Bjerkebæk, E. (2010). The influence on organizational accident risk by Integrated Operations in the petroleum industry. *Safety Science Monitor, 14*(1).

Hamel, G., & Prahalad, C. K. (1994). *Competing for the future*. Boston, MA: Harvard Business School Press.

Hansen, M. T. (2009). *Collaboration. How leaders avoid the traps, create unity, and reap big results*. Boston, MA: Harvard Business Press.

Henderson, J., Hepsø, V., & Mydland, Ø. (2012). *What is a capability platform approach to integrated operations? An introduction to key concepts.*

Hepsø, V. (2006). *When are we going to address organizational robustness and collaboration as something else than a residual factor?* Society Petroleums Engineers Paper 1000712. Presented at the Society of Petroleum Engineers (SPE) conference Intelligent Energy, Amsterdam, The Netherlands, April, 2006.

Intelligent Conference and Exhibition, Utrecht, The Netherlands, March 23-25 2010.

Johannesen, J.-A., & Rosendahl, T. (2010). *Prosjektkommunikasjon* [Project communication]. Cappelen Akademisk Forlag.

Kaarstad, M., Rindahl, G., Torgersen, G. E., & Drøivoldsmo, A. (2009). Interaction and interaction skills in integration operations. In *Proceedings of the 17th World Congress on Ergonomics, 9–14 August 2009*. Beijing, China: International Ergonomics Association. Leonard- Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, *13*(S1), 111–125.

Levin, M., & Rolfsen, M. (2004). *Arbeid i team: Læring og utvikling i team* [Work in team. Learning and development in team]. Oslo, Norway: Fagbokforlaget.

Lurey, J. S., & Raisingham, M. S. (2001). An empirical study of best practices in virtual teams. *Information & Management*, *38*, 523–544. doi:10.1016/S0378-7206(01)00074-X

Mintzberg, H. (1983). *Structures in fives: Designing effective organizations*. Englewood Cliffs, NJ: Prentice Hall.

Moldjord, C., Steiro, T. J., Firing, K., & Fredriksen, P. (2010). *Tough men cry. Learning from sharp end military aviation. ESREL 2010. September 5th-9th*. Greece: Rhodes.

Nemiro, J., Beyerlein, M., Bradley, L., & Beyerlein, M. (Eds.). (2008). *The handbook of high-performance virtual teams. A toolkit for collaborating across boundaries*. San Francisco, CA: Jossey-Bass.

Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review*, (May): 1990.

Ringstad, A. J., & Andersen, K. (2006). *Integrated operations and HSE – Major issues and strategies.* Paper, SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, Abu Dhabi, U.A.E., 2-4 April 2006. SPE 98530.

Ringstad, A. J., & Andersen, K. (2007). *Integrated operations and the need for a balanced development of people, technology and organization.* Paper, International Petroleum Technology Conference, Dubai, U.A.E., 4-6 December 2007. IPTC 11668.

Salaman, G., & Asch, D. (2003). *Strategy and capability. Sustaining organizational change*. Malden, MA: Blackwell Publishing.

Sandelands, L. E., & Boudens, C. J. (2000). Feelings at work. In Fineman, S. (Ed.), *Emotions in organizations*. London, UK: Sage Publications Ltd. doi:10.4135/9781446219850.n3

Skjerve, A. B., Albrechtsen, E., & Tveiten, C. K. (2008). *Defined situations of hazard and accident related to integrated operations on the Norwegian Continental Shelf.* Report no. NTNU/SINTEF/IFE – Program 4.3- Report no. SINTEF A9123 –2008.12.22. Open.

Skjerve, A. B., & Torgersen, G. E. (2007). *An organizational-pedagogical framework to support competence assurance activities*. Paper, ESREL (European Safety and Reliability Association) Conference 2007, 25-27 June, Stavanger.

Teece, D. J., & Pisano, G. (1994). The dynamic capabilities of firms. An introduction. *Industrial and Corporate Change*, *3*(3), 537–556. doi:10.1093/icc/3.3.537-a

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533. doi:10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Toffler, A. (1985). *Fremtidsglimt* [Future glimpse]. København, Denmark: Chr. Erichsen.

Torgersen, G. E. (2008). The idea of a military pedagogical doctrine. In T. Kvernbekk, H. Simpson, & M. A. Peters (Eds.), (2008). *Military pedagogies. And why they matter*. Rotterdam, The Netherlands: Sense Publishers.

Torgersen, G. E., & Skjerve, A. B. (2012). *Towards an IO pedagogy. Paper, project/work in progress. Institute for Energy Technology (IFE)*. Halden.

Torgersen, G. E., & Steiro, T. J. (2009). *Ledelse, samhandling og opplæring i fleksible organisasjoner* [Leadership, Interaction and Training in Flexible Organizations]. Stjørdal, Norway: Læringsforlaget.

Torgersen, G. E., & Steiro, T. J. (2010). *Interaction in complex organisations*. IMTA Conference, September 27 – October 1, 2010. Lucerne, Switzerland.

Volberda, H. W. (1999). *Building the flexible firm: How to remain competitive*. Oxford, UK: Oxford University Press. doi:10.1093/acprof:oso/9780198295952.001.0001

Woodward, J. (1965). *Industrial organization: Theory and practice*. London, UK: Oxford University Press.

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Section 6
Resilience and HSE

Chapter 20
IO, Coagency, Intractability, and Resilience

Erik Hollnagel
University of Southern Denmark, Denmark
& Norwegian University of Science and Technology, Norway

ABSTRACT

Technological developments continuously create opportunities that are eagerly adopted by industries with a seemingly insatiable need for innovation. This has established a forceful circulus vitiosus that has resulted in exceedingly complicated socio-technical systems. The introduction of Integrated Operations in drilling and off-shore operations is one, but not the only, example of that. This development poses a challenge for how to deal with risk and safety issues. Where existing safety assessment methods focus on descriptions of component capabilities, complicated socio-technical systems must be described in terms of relations or even functional couplings. In order to design, analyse, and manage such systems, it must be acknowledged that performance adjustments are a resource rather than a threat. Safety can no longer be achieved just by preventing that something goes wrong, but must instead try to ensure that everything goes right. Resilience engineering provides the conceptual and practical means to support and accomplish that change.

INTRODUCTION

The term Integrated Operations (IO) is by now firmly established within the off-shore industry and also slowly spreading to other industries. In recognition of this development, the purpose of this chapter is to consider what consequences IO has, or should have, for how we think of the off-shore industry as a system, specifically the ways in which safety issues are or should be treated.

Although the use of the term IO is widespread, and has been so for some years, that does not necessarily mean that it is well-defined. Indeed, at the time of writing this chapter (mid-2011) there does not seem to be any generally accepted definition. In one of the early documents (OLF, 2003), IO was described as the "processes and tools for effective real-time utilisation of increased data."

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Since then the meaning has become extended so that IO now is used as a rather generic term to cover most aspects of the oil and gas industry, especially the role of information, communication and cooperation (of the above-mentioned 'increased data') in off-shore and on-shore operations. It also covers a number of other aspects of oil and gas industry activities, including drilling operations, reservoir management, production optimisation, maintenance, and safety management.

IO was from the beginning promoted as an approach to increase the efficiency and safety of the industry (OLF, 2003 & 2005). Today it is also used in the broader sense as a characterisation of how the industry has developed from the mid 1990s and onwards. (As an aside, the practically uncontrolled use and dependence on information technology in the industrialised societies means that they also can be seen as an example of integrated operations, although by necessity rather than by intention.) This development has been driven by the enthusiastic use of the possibilities offered by cutting edge information and communication technologies. (These technologies are however not specific to the off-shore industry, which is why a similar trend can be seen elsewhere, for instance in health care.) The application of new technological solutions to improve the industry – not least the productivity – obviously affects everyday work processes as well. The increased integration has consequences for how resources are allocated and used (not least human resources), for how activities are planned and scheduled, for how downstream functions become dependent on upstream functions (and how difficult it becomes to predict outcomes of actions and interventions), and for how safety and effectiveness can be provided, managed, and maintained.

Thus, despite the uncertainty about what IO precisely is, the steadily growing use of IO has irrevocably changed how the industry operates. Because of that, it is necessary also to change the way in which we think of how the system works and how it can remain safe, in particular the way we describe it and the way we analyse it. This is so regardless of whether we consider a specific subset of the operations or whether we look at how the system functions as a whole.

RELOCATED SYSTEM BOUNDARIES

The oil and gas industry considered as a system, and using the term loosely, had become both larger and more complicated. If we use a classical definition of a system as "a set of objects together with relationships between the objects and between their attributes" (Hall & Fagen, 1969, p. 81) – or even more broadly as anything that consists of parts connected together – then the industrial systems of today have definitely become larger. The size or extent of a system is determined by how the boundaries are defined, i.e., where one considers that the system ends and the context or environment begins. These boundaries are however rarely absolute or well-defined, but depend on a number of considerations that have to do with concerns for safety, operations, or business. During the last 30 years or so, rampant technological and societal developments have together with rapid changes in the business environment made it necessary to enlarge the boundaries of the systems that we work with and need to control.

- A first extension has enlarged the boundary 'vertically' to include the entire system, from technology at the bottom to management at the top. (The terms 'bottom' and 'top' that normally are used to describe organisations imply a hierarchical structure, which does not necessarily correspond to reality.) Whereas it was common practice to limit efforts of both design and investigation to the so-called sharp end (Hollnagel, 2004; Reason, 1993), it is now necessary to look beyond the sharp end to include also the blunt end. Where it used to be sufficient to consider work at

the level of human-technology interaction, it is now necessary to expand the understanding to include both the basis for how the technology works and the basis for how humans work. The former is needed because the technology itself has become a complex system (cf., below) mostly due to the extensive reliance on various forms of computing machinery. The latter requires a change so that we no longer see humans as individuals, or in the worst case as human information processing systems (Rouse, 1981; Wickens & Carswell, 2006), but see them as parts of multiple social systems. In other words, we need to change from a description in terms of human-machine systems to a description in terms of socio-technical systems.

The idea of a socio-technical system is that the conditions for successful performance – and conversely also for unsuccessful performance – depend on the interaction between social and technical factors. The term socio-technical system is not new, but was used already in the 1960s by researchers from the Tavistock Institute of Human Relations in London, in particular Emery & Trist (1965) and Emery (1969), as a way of recognising the growing importance of the interaction between people and technology in workplaces. In line with the general principles of systems theory, the term 'socio-technical system' can be applied to specific systems – such as IO – as well as to society itself.

- A second extension has enlarged the boundary 'horizontally' from a focus on primary operations to a focus that more or less covers the whole life-cycle of the system. At first, the extension was needed to include both design and maintenance, since many operational events – mostly accidents and incidents, of course – only made sense if the latent outcomes of either design decisions or maintenance actions were included (Reason, 1997). But it is now accepted that the boundary has to be extended even further, from the initial feasibility study through the concept design study and the detail design, to construction and commissioning, then to operation, maintenance and modifications, to the final stages of decommissioning and abandonment.

This means that the time horizon of decisions in practice has become orders of magnitude larger, covering years or decades rather than days or months. One reason for this is the growing concern for the long-term environmental impact of industrial activity, which not least is relevant for off-shore operations. Another is that the rate of change, of both technologies and of markets, has increased, so that one can no longer assume that the conditions under which a system has been conceived or has to operate will remain stable. There are, for instance, a number of cases where equipment specified and ordered during the design of the system turns out to be outdated when it is taken into use.

- A third extension, also 'horizontal,' has enlarged the boundary from local operations to include both upstream and downstream processes. Processes and functions that previously could be treated as separate or loosely coupled (Perrow, 1984), have now become dependent or tightly coupled. An example of that is the 'just in time' (JIT) principle that is used in general production to eliminate the need for inventories (raw materials, spare parts, etc.), or the outsourcing of knowledge and expertise. (Another, and more scary, example, is the international financial system.) The upsteam-downstream coupling means that operations (or maintenance) have become so tightly integrated with a company's business, that we no longer can consider them without making sure first that the

upstream conditions are fulfilled and next that the downstream processes are not adversely affected.

The common sense meaning of 'integration' is to make something 'into a whole.' This means that parts that hitherto were considered separately, and that may also have functioned separately, become subsumed under a common framework. The simple fact of combining more parts within a whole means that there will be more connections and more dependencies. If the parts by and large are identical, the integration can be considered as a homogeneous system. In that case the main difference is one of scale, and the system is not necessarily more complicated. However, if the parts are of different types – or perform different functions – the integration will result in a heterogeneous rather than a homogeneous system. The integrated system will still be of a different scale, but will also be more complicated and possibly also less tractable. This is the case for IO.

FROM INTERACTION TO COAGENCY

The name IO in itself makes clear that it must be dealt with as a socio-technical rather than as a technical system. This means that the conditions for successful performance – and conversely also for unsuccessful performance – depend on the interaction between social and technical factors. (Notice the emphasis on social, rather than human factors. Whereas human factors focus on the characteristics – performance and otherwise – of individuals, social factors focus on the characteristics of humans as social groups, ranging from the dyad to a complete organisation – or even beyond that.) There are therefore two types of interaction that must be considered. The first is the interaction between people, which means how well they are able to work together, to interact and collaborate, to manage the social groups, to plan and schedule activities, to share and delegate authority, etc. The second is the interaction between the social groups and the technology, which in many cases may require a coordination of distributed activities. It is thus significantly different from the human-technology interaction that traditionally has been the object of study for human factors – and which, of course, still is needed.

Since technological artefacts function as state machines, and indeed have been designed as such, humans must also be treated as state machines (the so-called forced automaton analogy described by Hollnagel & Woods, 2005). When system design starts by the technology, we are willy-nilly forced to think of the user as a finite automaton because there is no other conceptualization or model that will fit the requirements of the design. This means that the focus is on how one unit works together with another, expressed in terms of a set of actions and interactions exemplified by the ubiquitous human-machine interaction. This term was originally used literally, to describe how people interacted with tools or machines, for instance a worker operating a lathe. In the 1980s the term was extended to include also human-computer interaction, although the computer mostly was a mediator for something else rather than the object of interaction itself. The interaction implies that there is a continuous exchange between human and machine as, e.g., in a dialogue, which consists of identifiable steps that can be described individually.

The alternative to describe work as the interaction between humans and technological artefacts is to focus on the performance of the system as a whole. This type of description refers to the concept of a joint cognitive system, as proposed by Hollnagel & Woods (1983). This puts the emphasis on the system's ability to modify its behaviour on the basis of experience so as to achieve specific anti-entropic ends. In basic terms this means that a joint cognitive system is able to

maintain order in the face of disruptive influences, specifically that it is able to control what it does. Cognitive systems appear to have a purpose, and pragmatically it makes sense to describe them in this way. In practice, the purpose of the joint cognitive system is often the same as the purpose of the human part of the system, although larger entities – such as organisations – sometimes seem to have purposes of their own.

Adopting the view of the joint cognitive system changes the emphasis from the interaction between humans and technology to human-technology coagency, i.e., joint agency. A joint cognitive system is not defined by what it *is*, but by what it *does*. The coagency comprises both linear (or trivial) 'cause and effect' relationships and 'non-linear' (or non-trivial) emergent relationships. Because of the latter it is no longer sufficient to describe and analyse system performance as if it was the product of interacting state machines.

Cognitive systems engineering and resilience engineering both make clear that outcomes are not always resultant but sometimes emergent. In most cases when something happens, an explanation is given in terms of how the system works, relying on the principles of decomposition and causality. In such cases the outcome is described as a result of the 'inner' workings of the system, or parts of it, and is therefore technically called resultant. There are, however, a growing number of cases where it is impossible to explain what happens as a result of known processes or developments. In such cases the outcome is said to be emergent rather than resultant. This does not mean that something happens 'magically,' but simply that it happens in such a way that it cannot be explained using the principles of decomposition and causality. This is typically the case for systems that in part or in whole are intractable, as described in the following.

FROM TRACTABILITY TO INTRACTABILITY

The established safety analysis methods embody a number of assumptions that were inherited from the large-scale technological systems of the late 1950s for which they were developed. Although these assumptions rarely are stated explicitly, they are easy enough to recognize in established methods such as FMEA (Failure Mode and Effects Analysis), HAZOP (Hazard and Operability Study), Fault Trees, etc. The four main assumptions are:

- Systems can be decomposed into meaningful elements (parts or typically components). Similarly, events can be decomposed into individual steps or acts. (The principle of decomposition is, of course, in conflict with the holistic principle that the whole is more than the sum of the parts.)
- Subsystems and components will either work or fail. In the latter case, the probability of failure can be analysed and described for each subsystem or component individually. This is part of the rationale for focusing on the human error probability, and indeed for classifications of human errors.
- The order or sequence of events is predetermined and fixed as implied by the deterministic design of the system. This leads to a representation in the form of trees of events. If a different sequence of events needs to be considered, it is necessary to produce a new version of the representation, e.g., a new event tree or fault tree.
- Combinations of events are orderly and linear. They can be described by standard logical operators, and outputs are proportional to inputs.

Although these assumptions may be warranted for technological systems, it is highly questionable whether they apply to social systems and organisations, or even to human activities as demonstrated by the reality of coagency and emergence. Models and methods that require that the system in focus can be fully described will therefore not be suitable for socio-technical systems, such as IO, neither for accident analysis nor for risk assessment. One way to highlight the difference between the two classes of systems is by characterising them as tractable and intractable, respectively. The differences are summarised in Table 1.

The differences described in the table above can be illustrated by two examples. First consider a tractable system, such as a car assembly line. Here descriptions are (relatively) simple with only a small number of details. Work is meticulously planned and scheduled so that the assembly can be as efficient as possible and produce cars of a high quality. The rate of change is low, and usually the result of a planned intervention. Work is dominated by routine and is therefore homogeneous and highly regular. Finally, since there is little, if anything, that is not understood in detail, comprehensibility can be said to be high. The system is tractable: it can be specified in great detail and decomposition is a natural approach to understand it better.

Next consider an intractable system, such as an emergency management room (EMR) in an on-shore installation, or for that matter an EMR anywhere. Descriptions of such systems are elaborate and with many details since work is non-routine and the same situation rarely occurs twice. The rate of change is high, which means that the system – and its performance – is irregular and possibly unstable. Unlike a car assembly plant, work in an EMR is difficult to plan because it is impossible to know what will happen, how many unexpected events – and consequences – there will be, and what kind of response they require. Finally, comprehensibility is low, because not everything is understood in detail. The system is intractable and underspecified. It is therefore not possible to describe it by decomposing it, nor would it make much sense to do so.

The partial loss of tractability is a cost that is necessary in order to achieve the desired gains in productivity, in quality, and in safety. However, in order to ensure that the integrated system can be managed efficiently and safely, it is necessary to know how the increased integration will affect both how the system functions and how it possibly can fail.

COMPLEXITY, IGNORANCE, AND VARIABILITY

Intractable systems are often also called complex. Indeed, complexity seems to be an undesirable yet unavoidable consequence of building large-scale socio-technical systems. Complexity theory and complexity sciences – or simply complex systems science – are therefore often looked upon as a source of potential solutions (Reference complex networks SESAR). Complexity is, however, not

Table 1. Tractable and intractable systems

	Tractable system	Intractable system
Number of details	Description are simple with few details	Description are elaborate with many details
Rate of change	Low; in particular, the system does not change while being described	High: the system changes before a description can be completed.
Comprehensibility	Principles of functioning are completely known	Principles of functioning are partly unknown
Characteristic of processes	Homogeneous and regular	Heterogeneous and possibly irregular

a well-defined concept, as the following definitions exemplify:

- Mathematical complexity is a measure of the number of possible states a system can take on, when there are too many elements and relationships to be understood in simple analytic or logical ways.
- Pragmatic complexity means that a description, or a system, has many variables.
- Dynamic complexity refers to situations where cause and effect are subtle, and where the effects over time of interventions are not obvious
- Ontological complexity has no scientifically discoverable meaning, as it is impossible to refer to the complexity of a system independently of how it is described.
- Epistemological complexity can be defined as the number of parameters needed to describe a system fully in space and time. While epistemological aspects can be decomposed and interpreted recursively, ontological aspects cannot.

The last two definitions are revealing, since they point out that complexity is inseparable from the way we describe what systems are and how they work. From a practical point of view, complex systems are therefore intractable, in part or in whole. Intractability is sometimes attributed to the degree of complexity of the systems we are dealing with, or simply to the purported fact that today's systems are – or have become – complex. Yet it is not clear what is cause and what is effect. It might justifiably be asked whether there is intractability and ignorance because the systems we deal with are complex, or whether we call the systems complex because we do not have – and possibly cannot have – complete knowledge about them.

In order for a system to be understandable it is necessary to know what goes on 'inside' it, to have a sufficiently clear description or specification of the system and its functions. The same requirements must be met in order for a system to be analysed and in order for its risks to be assessed. That this must be so is obvious if we consider the opposite. If we do not have a clear description or specification of a system, and/or if we do not know what goes on 'inside' it, then it is clearly impossible effectively to understand it, and therefore also to investigate accidents or assess risks. This lack of knowledge may refer to how the system works (i.e., then 'inner' mechanisms or the comprehensibility) or to what the consequences of specific actions and interventions will be.

While we may entertain the hope that complete knowledge in principle is possible for pure technological systems (barring the vagaries of software), there is no reason for such optimism in the case of socio-technical systems. Here ignorance is a fact of life because it is impossible fully to define or describe the parameters in space or time, even if we knew what they were. The main reason for this is not that there are too many parameters, but rather that the systems are dynamic, i.e., that they continuously change. There are, however, other reasons why we never have complete knowledge and therefore always to some extent will be ignorant. But while some degree of ignorance is unavoidable, some types of ignorance are less desirable – and more preventable – than others, as the following examples illustrate.

- True ignorance means that it is impossible both in practice and in principle to get complete information about how the system functions or even about how it is structured. In terms of outcomes, this corresponds closely to the category of unexampled events (Westrum, 2006), i.e., something that has never happened and for which there therefore can be no experience.
- Pragmatic ignorance means that it has been decided that for some things it is not necessary to know much – or anything – about them. Such decisions are, however,

always relative rather than absolute. They reflect the judgement that the benefits from spending additional efforts and time to find out something are of marginal value. This can be seen as representing a kind of efficiency-thoroughness trade-off, where thoroughness yields to efficiency (Hollnagel, 2009). If pragmatic ignorance is habitual, it becomes complacency.

- Finally, there is wanton ignorance, which means that it is decided *a priori*, rather than by a trade-off, that something is devoid of interest. This corresponds to Merton's notion of an "imperious immediacy of interest," which denote instances where a decision makers paramount concern with the foreseen immediate consequences excludes the consideration of further or other consequences of the same act (Merton, 1938).

CONCLUSION: FROM SAFETY TO RESILIENCE

Safety is traditionally defined by its opposite, i.e., by the lack of safety. If a situation or a system is unsafe, it means that something goes wrong or can go wrong. A safe system or condition is therefore one where little or nothing goes wrong. This is clear from the common definitions of safety. The U.S. Agency for Healthcare Research and Quality defines safety as "Avoiding injuries or harm to patients from care that is intended to help them." The International Civil Aviation Organization defines safety as "the state in which harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management." And in an off-shore context, (industrial) safety is defined as "the ability to manage the risks inherent to operations or related to the environment" (www.offshore-technology.com).

In consequence of such definitions, safety depends on the ability to prevent that something goes wrong. The focus of safety research is therefore that which goes wrong or could go wrong, such as near misses, incidents, and accidents. According to the traditional way of thinking, it is necessary to find the cause of what goes wrong in order to prevent it from happening again. Once the cause has been found, it must either be eliminated or possible cause-effect links must be disabled. If a cause cannot be eliminated, the alternative is to improve the protection against the outcomes. And finally, the result – increased safety – must be measured by counting how many fewer things go wrong.

Such a view in many ways is attractive, not least for its simplicity. This conception of safety, which can be called Safety-I, was developed for systems that can be nearly completely specified, i.e., for tractable systems. It is therefore also appropriate for such systems. But is is not possible to rely on the same approach for systems such as IO that in part or in whole are intractable. To be able successfully to cope with these, we need an alternative approach, which can be called Safety-II. Here safety is defined as the ability to succeed under varying conditions: the emphasis is on how things go right, how they work in the first place, rather than on how they fail. Safety-II is based on the principles of resilience engineering, where resilience is defined as "the intrinsic ability of a system to adjust its functioning before, during or after changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions" (Hollnagel, 2010). This definition emphasises the ability to continue functioning, rather than simply to react and recover from disturbances, and the ability to deal with diverse conditions of functioning, expected as well as unexpected. Resilience engineering as a discipline offers novel ways to confront the puzzles of complexity, interconnectedness, system of systems, and ultra high reliability (Hollnagel, et al., 2010).

One thing that characterises even partially intractable systems is that variability – in the form of performance adjustments on both an individual and collective level – is necessary for acceptable functioning under both regular and irregular conditions. Effective performance can therefore not be achieved by constraining variability. But established methods for system analysis, and especially for safety analyses, are unable to address this aspect of system functioning. Indeed, variability is almost by definition anathema to the traditional notion of safety (i.e., Safety-I). Resilience engineering provides a solution to this problem by emphasising that safety cannot be achieved only by preventing what goes wrong. In addition it necessary to ensure that the system can function effectively under both expected and unexpected conditions. The goals of resilience engineering are therefore congruent with the ambition of IO, namely to improve the overall performance of the system by facilitating "effective real-time utilisation of increased data."

The change from Safety-I to Safety-II, the change in the definition of safety from 'avoiding that something goes wrong' to 'ensuring that something goes right' – or even stronger, from avoiding that anything goes wrong to ensuring that everything goes right – has several interesting consequences.

- The purpose of Safety-I is to prevent something from going wrong, but not to make it more likely that something goes right. This is because Safety-I assumes that accidents and incidents have specific and identifiable causes, which should be eliminated or weakened. In contrast to that, Safety-II and resilience engineering both assume that everything basically happens for the same reasons, regardless of the outcome. In other words, there is not one set of causes or 'mechanisms' for things that go wrong (accident and incidents), and another for things that go right (everyday work).
- Safety-I assumes that safety can be improved by eliminating or weakening the causes of adverse events. This assumption implies the hypothesis of different causes, which proposes that the causes of adverse events are different from the causes of events that succeed. If that was not the case, then the elimination of the causes of failures would also reduce the likelihood that things could go right. The hypothesis of different causes is, however, not tenable, and the basis for Safety-I therefore disappears.
- The transition from Safety-I to Safety-II also diminishes the difference between safety and quality. The purpose of quality efforts is to ensure that things are done correctly so that nothing fails. The purpose of Safety-II efforts is similarly to ensure that things are done correctly so that that nothing fails. Quality and safety therefore in principle have the same purpose. (There are, of course, differences in the consequences of poor quality and poor safety – at least if we consider the immediate consequences – as well as differences in the means that traditionally have been applied). Yet if the purpose of quality and safety efforts are the same, then there is no good reason to use two different concepts. Safety and quality should thus no longer be pursued by two parallel tracks, but instead seen as two perspectives or interpretations of everyday work in a complex system.

In summary, IO in itself, as well as an example of a general trend in modern industries and societies, not only changes how large scale sociotechnical systems work, but also necessitates a change in how we should think about them. Such systems challenge the established models and methods, which rely on the principles of decomposition and causality. IO, however, is – almost by its nature – underspecified, heterogeneous, with a

high rate of change, and intractable. The alternative to the established methods is an approach based on resilience engineering principles. The most conspicuous difference is the change in safety practices from a Safety-I view to a Safety-II view and some of the consequences of this have been outlined above. Making this change is, however, not a choice but a necessity. Without that it will be difficult, if not impossible, to reap the full benefits of current and coming technological advances.

REFERENCES

Amaral, L. A. N., & Uzzi, B. (2007). Complex systems - A new paradigm for the integrative study of management, physical, and technological systems. *Management Science*, *53*(7), 1033–1035. doi:10.1287/mnsc.1060.0696

Emery, F. (Ed.). (1969). *Systems thinking*. Harmondsworth, UK: Penguin Books.

Emery, F., & Trist, E. (1965). The causal texture of organizational environments. *Human Relations*, *18*, 21–32. doi:10.1177/001872676501800103

Hall, A. D., & Fagen, R. E. (1968). Definition of system. In Buckley, W. (Ed.), *Modern systems research for the behavioural scientist*. Chicago, IL: Aldine Publishing Company.

Hollnagel, E. (2004). *Barriers and accident prevention*. Aldershot, UK: Ashgate.

Hollnagel, E. (2009). *Efficiency-thoroughness trade-off. The ETTO principle: Why things that go right sometimes go wrong*. Aldershot, UK: Ashgate.

Hollnagel, E. (2010). Prologue: The scope of resilience engineering. In Hollnagel, E., Paries, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice: A guidebook*. Farnham, UK: Ashgate.

Hollnagel, E., Paries, J., Woodds, D. D., & Wreathall, J. (Eds.). (2010). *Resilience engineering in practice: A guidebook*. Farnham, UK: Ashgate.

Hollnagel, E., & Woods, D. D. (1983). Cognitive systems engineering: New wine in new bottles. *International Journal of Man-Machine Studies*, *18*, 583–600. doi:10.1016/S0020-7373(83)80034-0

Hollnagel, E., & Woods, D. D. (2005). *Joint cognitive systems: Foundations of cognitive systems engineering*. Boca Raton, FL: Taylor & Francis Books, Inc. doi:10.1201/9781420038194

Merton, R. K. (1938). The unanticipated consequences of purposive social action. *American Sociological Review*, *1*(6), 894–904. doi:10.2307/2084615

OLF. (2003). *Edrift på Norsk Sokkel - Det tredje Effektiviseringsspranget*. Stavanger, Norway: Oljeindustriens Landsforening.

OLF. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf*. Stavanger, Norway: Oljeindustriens Landsforening.

Perrow, C. (1984). *Normal accidents: Living with high risk technologies*. New York, NY: Basic Books, Inc.

Reason, J. T. (1993). The identification of latent organizational failures in complex systems. In Wise, J. A., Hopkin, D. V., & Stager, P. (Eds.), *Verification and validation of complex systems: Human factors issues*. Berlin, Germany: Springer Verlag.

Reason, J. T. (1997). *Managing the risks of organizational accidents*. Aldershot, UK: Ashgate.

Rouse, W. B. (1981). Human-computer interaction in the control of dynamic systems. *ACM Computing Surveys*, *13*(1), 71–99. doi:10.1145/356835.356839

Westrum, R. (2006). Resilient systems. In Hollnagel, E., Woods, D. D., & Leveson, N. G. (Eds.), *Resilience engineering: Concepts and precepts*. Aldershot, UK: Ashgate.

Wickens, C. D., & Carswell, C. M. (2006). Information processing. In Salvendy, G. (Ed.), *Handbook of human factors and ergonomics* (3rd ed.). John Wiley & Sons, Inc. doi:10.1002/0470048204.ch5

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Chapter 21
IO Concepts as Contributing Factors to Major Accidents and Enablers for Resilience-Based Major Accident Prevention

Eirik Albrechtsen
SINTEF Technology and Society, Norway

Audun Weltzien
Norwegian University of Science and Technology, Norway

ABSTRACT

On the one hand, inadequacy of IO-concepts can, in combination with other factors, contribute to major accidents. On the other, work processes and technology within an IO-context contribute to prevent major accidents. This chapter shows how IO concepts can enable a resilience-based approach to major accident prevention by employing a case study of an onshore drilling center. Interviews indicate that drilling and well operations justify a resilience approach, as these operations are complex and dynamic. The case study shows how an onshore drilling support center facilitate adaptation to current and future situations at the sharp-end by providing decision-making support for the sharp-end by its ability to monitor what is going on, anticipate future developments, and look into past events and data. By use of the case study resilient capabilities and their required resources are identified. To ensure that inherent organizational resilience is managed and maintained adequately, there is a need to: 1) identify and refine inherent resilient capabilities and resources; and 2) develop methods and tools to manage resilience.

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INTRODUCTION

The recent introduction and development of IO-concepts, i.e. work processes and technologies for smarter decisions and better execution, enabled by ubiquitous real time data, collaborative techniques and access to multiple expertise (IO center, 2011), in the offshore oil and gas industry represent a Janus-face for major accident prevention. On the one side inadequacy of IO-concepts can, in combination with other factors, contribute to major accidents. On the other side, work processes and technology within IO contribute to prevent fatalities, severe injuries, environmental discharges and major material losses e.g. by improved decision-making by e.g. access to real-time data and access to expertise.

There are many claims that IO among other things results in improved HSE performance (e.g OLF, 2007). Often, this promise is justified by showing a reduction in lost-time injury rates or other occupational accident statistics. However, history has shown that good occupational accident statistics do not necessarily reflect a low risk for major accidents. Major accidents have happened in systems with good occupational accident statistics, e.g. Texas City refinery explosion (Hopkins, 2009). The same story applies to the Deepwater Horizon accident. The installation had a low lost-time injury rate prior to the blowout in April 2010. The investigation reports from the Deepwater Horizon accident as well as from the Montara blowout in 2009 and the near accidents at Snorre A in 2004 and Gullfaks C in 2010 show that what can be characterized as IO-related processes and technology have been significant contributing factors to these incidents, e.g. inadequate information flow between distributed actors and lack of involvement of onshore experts.

The investigation reports from the above mentioned incidents show that there have been deficiencies in the safety management systems, e.g. related to risk assessments, safety training, management of change, collaboration between different actors and flow of safety-related information (Tinmannsvik et al., 2011). For complex and dynamic socio-technical systems, Woods and Hollnagel (2006) claims that conventional safety management approaches are insufficient as they are mainly based on assumptions and models of systems being linear and simple. The approaches and methods applied in safety management need to be powerful enough to match the context of the system to be controlled. A resilience-based approach to safety management is one way to cope with the challenges of complexity, dynamism, conflicting tasks and unanticipated events (Woods and Hollnagel, 2006) On the one hand side IO-concepts contribute to these challenges, but on the other hand they are enablers for a resilience-based safety management approach which makes it possible to cope with theses challenges.

By employing a case study of an onshore drilling center, the purpose of this chapter is to elaborate on how IO concepts can enable a resilience-based approach to major accident prevention. The chapter first identifies how IO concepts influenced the blow-out incidents at Macondo, Montara, Snorre A and Gullfaks C. With these incidents as a rationale it is argued that a resilience-based approach to major accident prevention is needed as a supplement to traditional approaches. By use of a case study of an onshore drilling center it is shown how IO concepts can enable resilience-based safety management.

IO-RELATED WORK PROCESSES AND TECHNOLOGY IN RECENT MAJOR ACCIDENTS

There have been few attempts to link the development and implementation of IO concepts with major accident risk. Major accidents in the oil and gas industry happen seldom, however when they do happen the consequences are severe. No major accidents or near accidents are wanted, but when they occur they represent opportunities to learn and

improve the process safety performance. Major blowout incidents that have happened in the IO era provide indications on what role characteristics of IO concepts have played in these incidents. IO as a concept is not been explicitly touched upon in the investigation reports from these incidents, but several concepts that can be characterized as IO are found in the reports. Tinmannsvik et al. (2011) have made a thorough review of investigation reports for the Deepwater Horizon accident (2010), the Montara accident (2009), the Snorre A near-accident (2004) and the Gullfaks C near-accident (2010). This report is the result of a multidisciplinary comparison study of these incident ranging from drilling and well operations, the BOP, process integrity, stability; maintenance, emergency preparedness and organizational and management issues. The review by Tinmannsvik et al. (2011) shows a complex picture of different and interrelated contributing factors to the incidents. Without going into details here, the review show that some of the contributing factors leading up to the events can be characterized as being related to IO:

Inadequate Flow of Information between Actors

One of the aims of the implementation of IO is to improve sharing of information between several actors, improve presentation of information and ease access to information. Studies by Turner and Pigdeon (1997) show that poor information, inadequate distribution of the information and inadequate interpretation of information very often are contributing factors to major accidents. Inadequate flow of information is also a major contributing factor to the blowouts mentioned above. Investigation reports after Deepwater Horizon accident show that compartmentalization of information and lack of communication between actors were major contributing factors (Chief Counsel, 2011). For example, the BP onshore team was aware of the increased risk due to the cementing, but did not inform offshore crew members about this increased risk. If informed, it is likely that the crew would have increased their vigilance and could have detected and stopped the chain of events. Similarly, there were poor flow of information between night and dayshifts; and onshore and offshore teams operating at the Montara well (Montara Commission of Inquiry, 2010). Also for the Gullfaks C incident, there was inadequate transfer of information about prior experiences on measured pressure drilling (MPD) as well as previous events (PSA, 2010; Statoil, 2010)

Inadequate Involvement of Experts in Decisions

By improving and implementing collaboration technology, it is stated that decisions will improve in an IO-context by e.g. involving onshore-based experts in the decision-making processes. However, it is not much help if the easily available experts are not being involved in the decisions being made. Investigation reports after the Gullfaks C incidents show that there has been low degree of involving MPD experts in planning, risk assessments and operational follow-up of the MPD-operation (PSA, 2010; Statoil, 2010). Also in the time before the gas blowout at Snorre A there was lack of involvement of experts in risk assessments and training (Schiefloe & Vikland, 2005). It was the same problem with involving experts for decision-making support in the Deepwater Horizon accident, e.g.no experts were being contacted for assessing abnormal data from the negative pressure test (Chief Counsel, 2011).

Inadequate Onshore-Offshore Integration

The contributing factors mentioned above is related to the relationship between offshore and onshore groups. The integration between offshore and onshore had been poor prior to the Deepwater

Horizon accident. BP had, as an example, inadequate procedures on when offshore personnel should contact onshore personnel (Chief Counsel, 2011) Interviews performed after the Snorre A incident indicate that poor collaboration between offshore and onshore happened among other things due to lack of understanding of the local offshore conditions among onshore workers (Schiefloe & Vikland, 2005).

Inadequate Interpretation of Data

The IO development implies more real-time data and information available to more people. Adequate interpretation of this information must be facilitated. One of the key questions after the Deepwater Horizon accident is why the drilling crew and the mud logger did not react to anomalous data signals and kick signals in a period of nearly 50 minutes before the explosion. There was clearly data indicating that things were not as they were supposed to do, but one is reacting to it. Chief Counsel's report (2011) indicated that reduced awareness among the crew, simultaneously operations and poor human-machine interface contributed to the lack of detection. More access to data and information does thus not necessarily result in improved decision-making.

RESILIENCE-BASED SAFETY MANAGEMENT IN INTEGRATED OPERATIONS

The emergence of a resilience-based approach to safety management is a response to the inadequacy of conventional safety management approaches with regard to complexity and dynamics in socio-technical systems (Woods and Hollnagel, 2006). In the described blow-out incidents in the prior section inadequate abilities to handle and assess changes and to get a total overview of changes and risks in a complex system are central basic causes. As a result, it can be argued that a resilient-based approach to major accident prevention is a necessary supplement to conventional approaches.

Resilience can be understood as the intrinsic ability of a system to adjust its function prior to, during, or following changes and disturbances so that it can sustain required operations under both expected and unanticipated conditions (Hollnagel, 2011). Conventionally, safety has been understood as 'freedom from unacceptable risk'. However, the later years a new approach to safety management, resilience engineering (e.g. Woods, 2005; Hollnagel et al. 2006), has focused on safety as closely related to core processes of a system thus arguing that safety is 'the ability to sustain required operations under both anticipated and unanticipated conditions' (Hollnagel, 2011).

Resilience-based safety management can be interpreted as the totality of activities conducted in a more or less coordinated way to control hazards and vulnerabilities in such a way that accidents, failures and disturbances are either avoided or dealt with in a manner that makes systems sustain required operations. Safety management consists of a wide range of elements (Reiman and Oedewald, 2009), e.g. training, risk management, manager's commitment; procedures. In a resilience-based approach to safety management, these methods, tools and processes will seek to strengthen and maintain a resilient system. A resilient system adapts to different, both anticipated and unanticipated, situations in order to maintain its functioning based on four interdependent main capabilities, the four cornerstones of resilience (Hollnagel, 2011):

- Responding to regular as well as irregular variability, disruptions, disturbances and opportunities either by adjusting performance or by activating response plans
- Monitoring what changes or may change so much that it will require a response. The monitoring must cover both what is going in the environment as well as own performance

- Anticipating future developments, threats and opportunities
- Learning from experiences, both successes and failures

In the resilience literature, the cornerstones are usually denoted as abilities (e.g. Hollnagel, 2011). These abilities are quite similar to capabilities, which Henderson et al. (this book) define as "a set of interdependent activities involving people, process, technology and governance that directly creates economic value". There are however some nuances that differ resilience approaches from capability approaches. First, having in mind that safety is a dynamic non-event (Weick and Sutcliffe, 2001), it can also be argued that safety is not only something you do, it is also an inherent quality that pervades all aspects of practice. Resilient abilities are thus not only activities (actions), they are also inherent qualities of an organization related to e.g. risk awareness and readiness to respond. Second, resilience-based safety management aims at both protection and production, i.e. not only creation of economic value. History has shown that too much focus on production and efficiency compared to safety leads to accidents (Rasmussen, 1997; Reason, 1997). However, a resilience-based approach states that the same processes and technologies that creates accidents as well as innovation. The adaptation to situations is the reason why things usually go right and why things sometimes go wrong. A resilience approach does not only focus on preventing things from going wrong but also ensure that things go right by facilitating normal outcomes. Things that go wrong is the flipside of things that go right, it is thus the same underlying processes behind both (Hollnagel, 2011). Third, both resilience approaches and capability approaches focus on non-instrumental approaches to adaption. Both approaches are a response to cope with complexity, however resilience approaches are also aiming to cope with performance variability and change. Despite these minor differences between resilience abilities and the definition of capabilities by Henderson et al. (this book), the cornerstones of resilience are denoted as capabilities in this book chapter.

Why Resilience-Based Approaches in IO?

Hollnagel et al. (2010:6) states that a simple answer to this question can be found "by looking at the types of accidents that can occur in complex yet 'well-defended' systems, of which Integrated Operations is a good example. While incidents such as the Snorre A gas leak with hindsight can be explained by failure modes emerging from the weak interaction of multiple factors, few would have considered this situation credible ahead of time. Traditional thinking makes it difficult to describe and understand how multiple factors can come together in time and space to produce something as disastrous as a blow-out". In a study of resilience abilities in the Deepwater Horizon accident and the Snorre A near-accident, Andersen and Albrechtsen (2011) show inadequate capabilities to monitor, anticipate and learn for both accidents. The response and adaptation to the situation was successful at Snorre A, however on the Deepwater Horizon there was no response being performed. For both incidents, improved capabilities to monitor, anticipate and learn would have initiated an earlier response and heightened vigilance to hazards and warnings and thus dealt with the situation in earlier stages.

As industrial systems continue to become more complex, new and supplementary approaches to safety management are needed. More complex structures of systems make them difficult to understand and control. Adding performance variability (individual and collective adjustments to match current demands and resources to ensure that things go right) to the complex characteristics make the systems dynamic and only retrospectively coherent (Grøtan and Størseth, 2011).

Performance variability implies that procedures and instructions are always incomplete,

expect for extremely simple situations (Hollnagel et al., 2010). Following procedures to the letter will be inefficient or unsafe. To compensate for this incompleteness individual and collective adjustments are made to produce successful outcomes. As a result, there is a need for adaptation to cope with complex, unanticipated, interleaved and conflicting tasks. For such systems, safety management needs to balance and integrate compliance and resilience in a careful manner (Grøtan and Størseth, 2011).

CASE STUDY: RESILIENCE IN PRACTICE AT AN ONSHORE DRILLING CENTER

To illustrate how IO-concepts can be resources that enableresilient capabilities, results from a case study by Welztien (2011) showing how resilience is generated and maintained in well operations through use of collaboration technology is presented here. The case study, based on observations and interviews, was performed at an onshore drilling center as the core object of study. The function of the center is basically to support offshore drilling and well operations. The center consists of inter-related rooms aiming at improving decision-making g processes and results. Disciplines such as operational geologists, data engineers and directional drillers work in the center.

The case study data was collected by qualitative interviews and observations of work practices. The observations were done by studies of workers during daily work and attending to meetings. The observer took on a researcher role rather than a participant role, even though some questions were asked to the employees who then described aspects of their work to the researcher and sometimes also demonstrated tools they use in their work. Fifteen qualitative interviews were conducted face-to-face at the case company and the service companies' offices. The interviewees were employees possessing different roles within drilling and well operations in the case company and its contractors, with a focus on the onshore organization. One of the interviews was with an offshore employee, but some of the other interviewees had worked offshore earlier in their career. Twelve of the interviews were directly focused on answering the research questions, while three aimed at getting an understanding of the organization's systems and processes.

The results of the case study is interpreted and presented by employing the four cornerstones of resilience: monitoring, anticipating, responding and learning. The cornerstones are interlinked and it is hard to keep them mutually exclusive. Nevertheless, for reasons of simplicity, it has been attempted to categorize them according to the four cornerstones. Before presenting the resilient capabilities within the drilling and well organization identified in the study, signs of variability in drilling and well operations are presented.

Uncertainty and Variability in Drilling and Well Operations

The interviews indicate a wide range of factors that cause challenges during drilling and well operations. Conditions downhole were by nearly all respondents mentioned to be uncertain and a source of surprises. Software, measurement tools, well construction and design, and drilling equipment are also stated to be a group of factors that may make drilling and well operations uncertain and risky.

Many interviewees point at the uniqueness of every well as a key contributor to uncertainty. Historical data from similar wells may not always provide sufficient information in order to solve a given situation. Understanding the geological models and processes in addition to being able to assess and understand the situation properly is regarded as difficult. Combinations of expert knowledge, individual skills, information from measurements and collaboration is claimed to

be necessary preconditions for successful interpretation and assessment. Some of the physical processes in the reservoirs can also occur because of changes in the activities related to the oil exploration and production. Pumping hydrocarbons affect the pressure in the reservoir and may change the behavior of the formations and fluids in the reservoir. Water and gas injections may affect this additionally. Three short citations from the interviews illustrate short and neatly the performance variability in well and drilling operations: "things never go according to plan"; "…changes and unknowns happen constantly"; and "..changes and adjustments happen all the time". One interviewee emphasized that (citation) "drilling is a very dynamic system, with high degree of interdependency", and that one "cannot optimize one part of the system without taking into account the effects on the other parts.", suggesting that a holistic approach is necessary to avoid sub optimization.

In short, the interviews show that drilling and well operations are complex and dynamic processes where unanticipated situations occur often. In this context, adaptations are required. Based on these empirical findings it can thus be interpreted that it seems that drilling and well operations justify a resilience approach to facilitate efficient adaptation to changes, disturbances and unanticipated situations.

Monitoring What is Going On

Real-time data and data logs from daily offshore operation are submitted to onshore databases, e.g. parameters like temperature, flow, depth, rate of penetration, torque and drag forces, and gas volume. A group of the onshore engineers in the contractor's support center monitors this real-time. Their main task is to support the driller and serve the rig crew by identifying problems and trends, and recommend interventions and actions. Another group of drilling technology engineers performs deeper analyses of the data material. Together, these analyses and recommendations, based on both historical and real-time data, serve as operational decision support and guidance to the offshore drilling crew.

The drilling contractor's onshore team is more concerned with supporting the tool pusher/drilling supervisor and has direct contact with the driller. They are "the driller's second pair of eyes", as one of the support engineers put it. Sensor data is displayed in the driller cabin, but due to many other tasks and responsibilities of the driller, onshore monitoring support is needed.

Onshore monitoring of offshore performance data improves the decision-making support and the capability to adapt to all types of situations in order to prevent things from going wrong and maintain successful operations. Not least because the capability to detect abnormalities and trends improves. In the onshore center, people from different disciplines can view the same information together. Engineers sitting in the same open office, collaborate tight. As they work with the same type of problems, often on the same project and even cooperating on the same specific analysis – they seemed to naturally support each other with feedback and tips. The interviewed engineers claimed that working in such open-plan offices makes it feel natural to ask colleagues for help and feedback, since both the physical constraints and social barriers are broken down in such an environment. Another factor contributing to collaboration was the regular, formal meetings that take place between actors and groups. Video conferences with people offshore and meetings with personnel from other onshore teams was not only an arena for discussions and sharing of information, but it was also reported to increase communication between the formal meetings. Decision-making support was thus generated through the development and use of complementary knowledge

Anticipation of Future Developments, Threats, and Opportunities

Signs, cues and recognized patterns in the data do not only give valuable information about the present situation and immediate responses. They also enable the organization to anticipate things that may occur in the future and prepare for coping with possible challenges and opportunities. Recognition of phenomena and situations that are about to occur may indicate that hazardous situations are developing. When pre-warnings of such events are recognized, resources can be allocated so that monitoring can be increased and responses prepared. The interviews indicate that data engineers from the onshore support center as well as from the drilling contractor's onshore center can direct their attention more towards specific activities and give the rig extra support if needed. It was stated that it possible for the onshore team to put aside other work tasks for a period of time, representing some buffering capacity. By having this opportunity the engineers can focus their work on problems they suspect may happen and prepare solutions to cope with the possible challenges.

Besides the information that continuously flows from the sensor situated downhole in the given/present well, data from similar wells are used for anticipation purposes. The experience from past drilling operations gives important input to planning and preparations of the future drilling operations. Data logs, daily reports, specific reports from analyses, recommendations and learning from incidents provide useful input to the planning, drilling and operation of future wells. The collecting and storing of this information for later use is described in the following section on learning.

Support engineers compare trends and patterns from current data with historical data. When recognizing a possible problem the optimization engineers search for historical data on similar successful runs and things to watch out for. Combined with their tacit knowledge – and often after consulting colleagues – they recommend how to handle coming operations. Data interpretation is a key here to understand current situations and anticipate increased risk. Some of the interviewees tell about a number of factors and phenomena that influence each other that are not – and perhaps cannot be – written in procedures or guidelines. Several phenomena have natural explanations, they say, like conditions downhole that may explain a certain change in one parameter. Well specific design may vary significantly from well to well and modifications made during the well operations may lead to changes in the values that need to be accounted for.

Even though the onshore support center fulfill the anticipation function to a great degree, the driller and the offshore drilling team still play a role in addressing potential problems, the interviews indicate. The practical experience gained from offshore work enables the driller to interpret signals and cues and anticipate upcoming events.

Responding to Regular and Irregular Disruptions, and Disturbances

As described, the interviewees explain drilling and well operations as a dynamic process implying performance variability of fluctuating amplitude. These variations must be responded to by the system. The monitoring of the drilling process and anticipation of events make the system able to catch signals of hazardous situations, and make early warnings to determine responses. Rules and guidelines have been developed to indicate required responses. Some requirements are detailed and strict, for instance acceptance/threshold values for drilling parameters or how to perform function tests in a well control situation. Most of the rules and procedures allow some degree of individual assessment and situational adjustment. According to the interviewees, one has to rely on individual workers' assessments

and adaptations to a great extend because of all the variations. However, since more people are seeing more of the same information and doing different analyses a response does not solely rely on single persons. By looking over each others work and discussing the solutions with colleagues the onshore support center functions as a whole team of experts.

The onshore support center is given the responsibility to give expert analysis and advices to the offshore crew. However, it is the driller who has the decision-making authority and utilized recommendations and advices from onshore personnel as well as offshore personnel. An offshore team consisting of driller, tool pusher and offshore data engineers monitors and interpret information they receive and initiate responses when required. The other main source of response support is warnings and recommendations from engineers in the onshore support centers. As described in a previous subsection, onshore engineers do various analyzes and provide advices and recommendations during operation. Many of those recommendations are within the decision latitude of the rig crew and can be implemented immediately, rejected or put "on wait" for more assessment. Governing documentation determines where rules to comply with are defined and where there is room for individual assessment/decisions/actions.

The onshore engineers keeping an eye on the operations and supports the rig team has a rather high degree of flexibility with respect to organization of their work and allocation of their resources. They can draw their attention to problems that occur and in this way allocate resources to urgent things. During normal operation they have the flexibility to focus on areas they feel there is a need to monitor or do analysis. This is particularly true for the optimization engineers. The interviews indicate that both the offshore team and the onshore support team need to be flexible in order to deal with the dynamic nature of drilling and wells operation.

Learning from Experience

The interviews indicate that utilizing the lessons learned from past operations is one key to successful drilling of a well. The interviewees state the importance of learning on the job site and being able to make good use of that knowledge. Work practice is emphasized as the most valuable source of knowledge.

Real time data is stored in databases and can be accessed at a later point in time which allows the workers to check data from previous operations and perform new analysis on the historical data. An important part of the optimization engineers' job is to document their findings from pre-run and post-run analyses. By documenting the parameter values from a given situation and the recommendations they made together with the outcome and lessons learned from the run, that information can be used later projects. Interviewees point at data from the wells in the same area as the most similar and relevant, and therefore documentation of previous operations is seen as very valuable.

Post run analysis is performed by drilling optimization engineers after a run. Data collected from real time sensors and logs from down hole are analyzed. The data are compared with the goals and plans for the run and with data from similar runs. When the analysis is performed one can, according to the interviewees, extract valuable information for use in later runs and for other wells. By documenting and sharing lessons learned, one lays a foundation for successful runs in the future. In addition to the reports and procedures that are available, the knowledge of the individual employee also plays a significant role. First, much knowledge from the engineer that is not explicitly written down is useful when applying the procedures and lessons learned in future runs. Second, when performing future post run analysis this knowledge can be utilized and give even better documentation of lessons learned.

FACILITATING RESILIENT WELL AND DRILLING OPERATIONS IN IO

For drilling and well operations in particular and for complex and dynamic socio-technical systems in general, it is required to supplement conventional safety management approaches with resilience-based approaches. Well and drilling operations at the sharp end are, as shown by the case study, dynamic processes with high degree of performance variability occurring constantly. Adaptation is required in order to cope with variations in complex socio-technical system, e.g. related to geological conditions in the reservoir, drilling equipment, human performance and inter-dependent interactions among actors. The range of possible outcomes during the operations is wide and uncertain, which makes it challenging to control all possible outcomes. For situations with high performance variability, individual and collective adjustments to match current demands and resources to ensure that things go right are required. Under such conditions, following procedures to the letter can be inefficient or unsafe (Hollnagel et al., 2010). To compensate for this incompleteness individual and collective adjustments are made to produce successful outcomes. A resilient system will facilitate such adaptations, and make it possible to solve problems efficiently and thus bounce back to normal operation and successful outcomes as fast as possible. The case study in this chapter shows how a particular IO context, onshore drilling support, improves resilience in drilling operations.

Recent blow-out incidents (Deepwater Horizon, Montara, Snorre A, Gullfaks C) show that IO-related factors such as inadequate information flow; poor communication and collaboration between distributed actors; and inadequate involvement of onshore-based expertise in combination with other factors can lead to such events. These incidents have severe damage or with high potential for severe consequence, but are low frequent events. One should thus not only learn from the things that go wrong as they happen seldom. It is the same underlying processes that create failure that create successful outcomes (Hollnagel, 2011). In order to improve the safety performance in an IO-context one also should study successful outcomes. Following a resilience-based approach to safety management, one should also consider normal operation to understand and facilitate how major accident risk is reduced by inherent resilient capabilities in work processes, as shown by the case study.

The case presented in this chapter gives indications on how IO can enable resilience in daily operations and thus reduce major accident risk. The case study shows how an onshore drilling support center facilitates resilient drilling operations at the sharp-end by providing valuable decision-making support for the sharp-end by their capabilities to monitor what is going on, anticipate future developments and look into past events and data. This onshore support facilitates adaptation at the sharp end, which the interviewees claim is required for the dynamic and complex nature of drilling and well operations. The resilient capabilities inherent in the onshore support centers, are further strengthened by multi-disciplinary team work and flexible capabilities to pay attention to critical events. As a result the drilling crew is better equipped to adapt to current and future situations. To interpret how IO concepts enable resilience, the capability framework by Henderson et al. (this book) is applied on the studied case in the following.

The core capability addressed in the case study is the intrinsic ability of the drilling organization to adjust its function prior to, during, or following changes and disturbances so that required operations can be sustained under both anticipated and unanticipated conditions, i.e. to be resilient. The study is delimited to the onshore drilling support center. Based on the cornerstones of resilience presented in previous sections in this chapter, a resilience capability can be divided into interdependent sub-capabilities, see Figure 1.

To the left in Figure 1 is the 3-layered simplified capability stack provided by Henderson et al. (this book). To the right is a resilience capability stack, which mirrors the capability stack. Foundational capabilities are not included in the resilience capability stack, but are a prerequisite for parts of the resilient capabilities, e.g. quality of data. They are thus included as capability resources.

The capability framework by Henderson et al. (this volume) suggests to look into the details of sub-capabilities by clarifying different resources (related to technology; process; people; and governance/organization) of each sub-capability. The case study presented in this chapter, gives indications on what resources that needs to be in place for the resilient sub-capabilities in Figure 1. The results of this exploration are presented in Figure 2, 3, 4, and 5.

The four resilient sub-capabilities (response, monitoring, anticipation, and learning) are closely interlinked. To illustrate this, the capabilities are classified as resources to each other in the resource group 'government/organization'. What you look for in the future (anticipation) is e.g. dependent on what have happened in the past (learning); current activities (response); and performance signals from current activities (monitoring).

The capability resources are also interrelated and several of the resources are related to all the sub-capabilities. There are also overlap between

Figure 1. Resilience capability stack

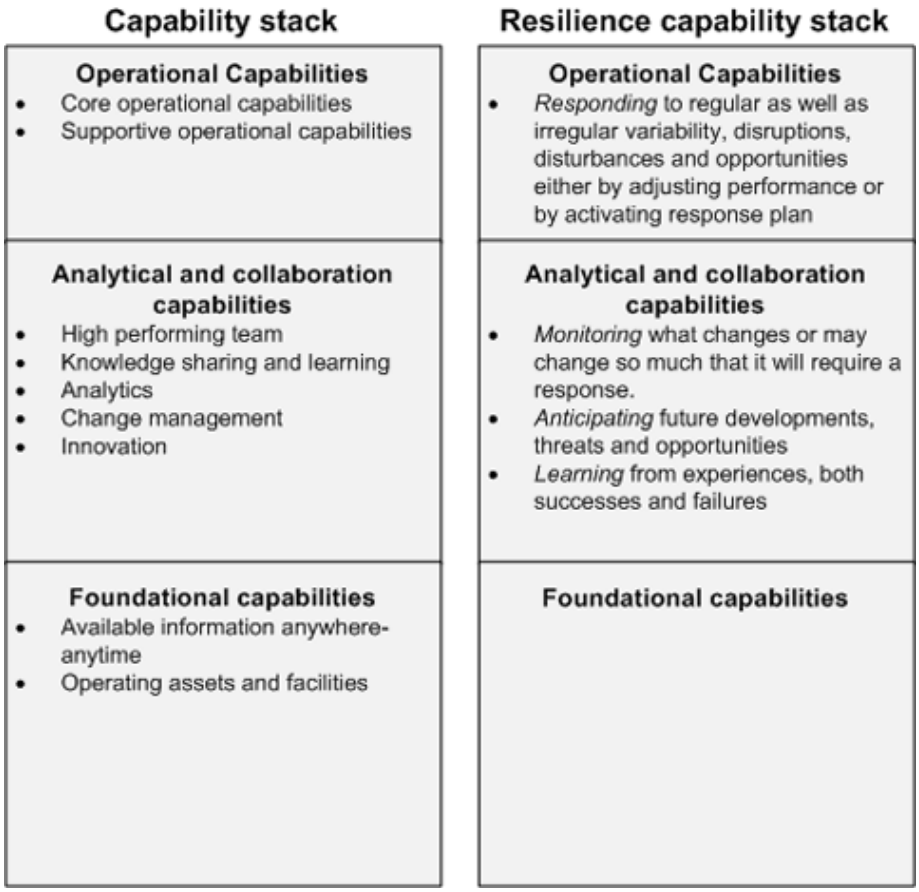
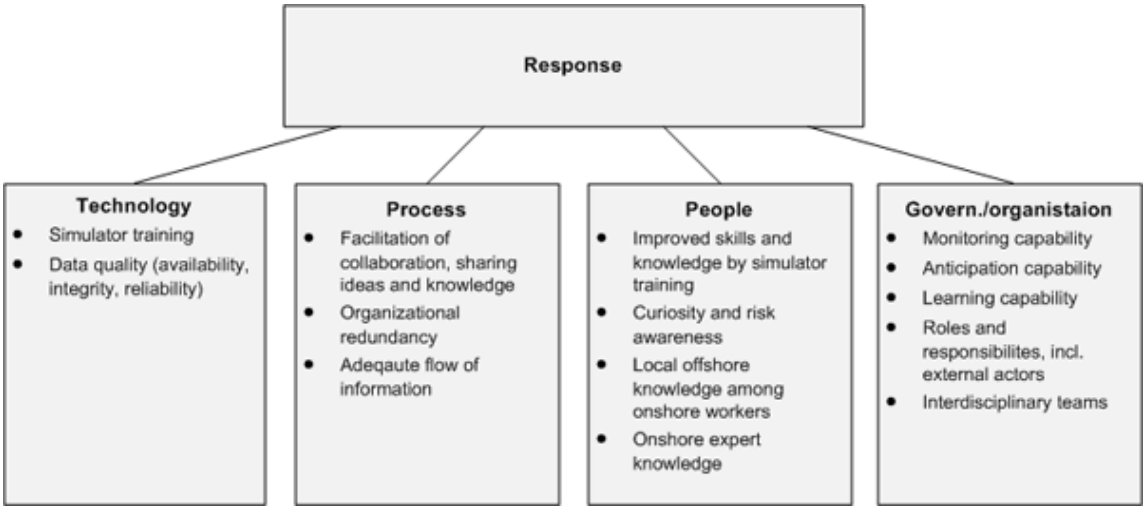


Figure 2. Resources for the capability to respond in the case study



the resource groups, e.g. information flow is placed as a process, but could very well have been placed in the technology resource group.

The case study shows that a working environment facilitating collaboration, sharing of ideas and knowledge is central resource for resilience, including organizational redundancy where employees can share their own views, ideas and tacit knowledge with colleagues. In the case study this is enabled by teams of experts in open space offices, where colleagues can look over each other's work and give feedback. Furthermore, organizational processes that facilitate collaboration, like planning meetings and evaluations are an important resource for resilient capabilities.

Figure 3. Resources for the capability to monitor in the case study

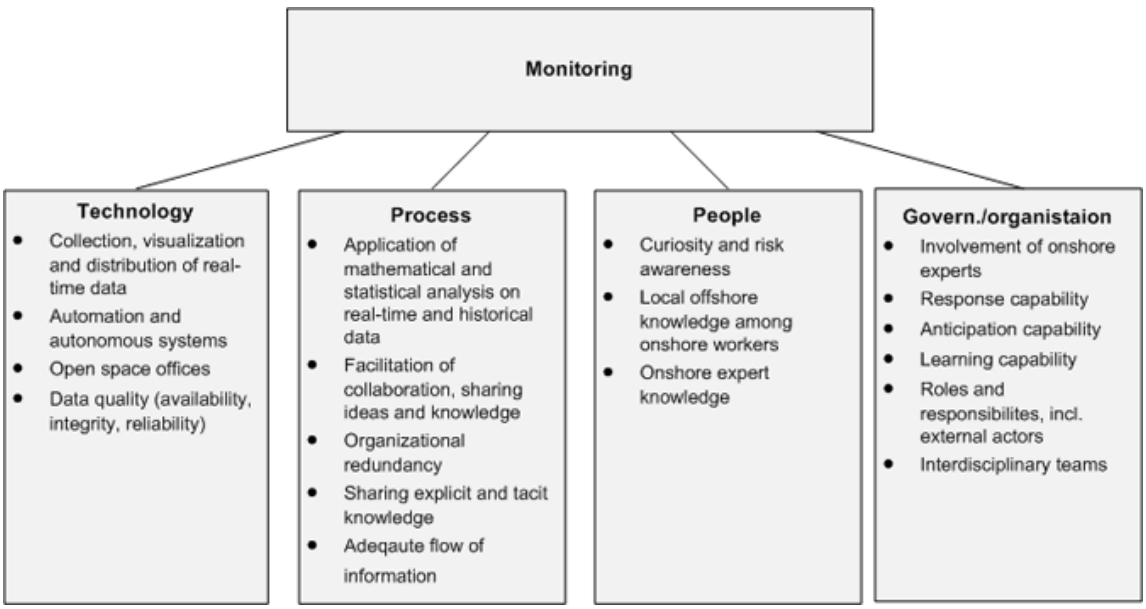
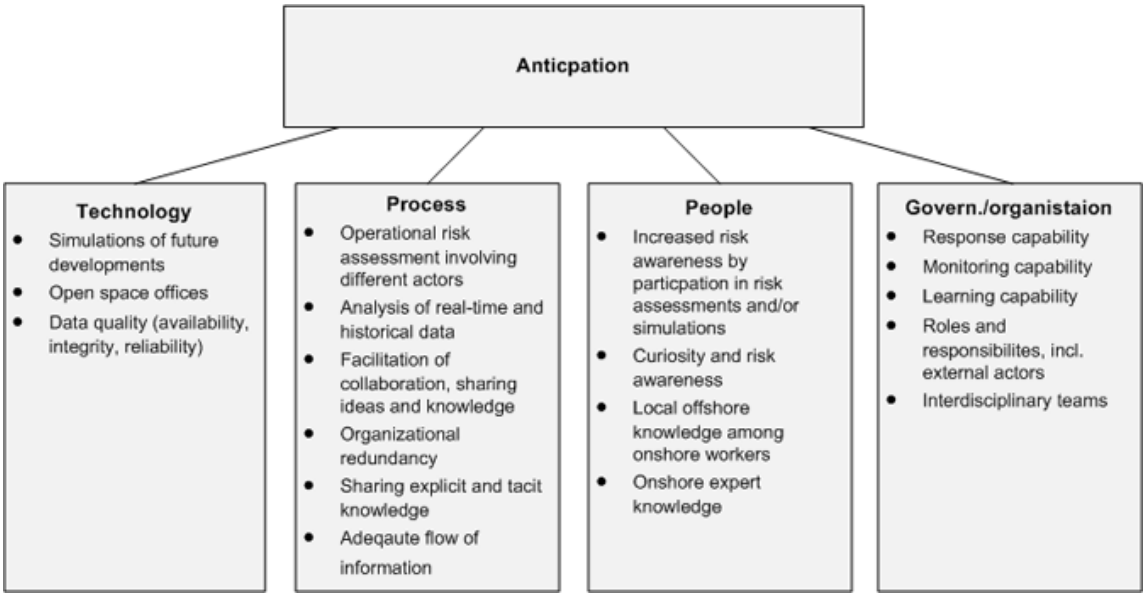
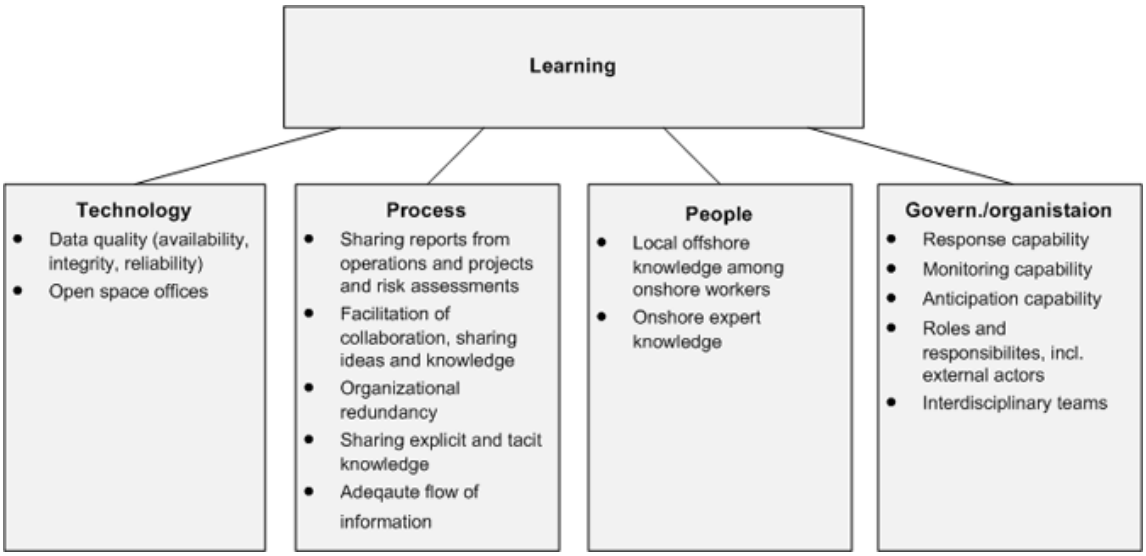


Figure 4. Resources for the capability to anticipate in the case study



Regarding monitoring and anticipation, extensive use of statistical and mathematical analysis on real-time as well as historical data may serve as valuable decision support during planning and operation. Based on an interpretation of recent blowouts in an IO perspective, Andersen and Albrechtsen (2011) point at the need for improved operational risk assessments involving different actors. Collaboration technology, access to experts and improved data material could enable such a development. Simulating future developments during operation would also improve the anticipation capability.

Figure 5. Resources for the capability to learn in the case study



Improved flow of information between actors is mentioned as a resource for resilience in an IO context by Andersen and Albrechtsen (2011). The case study pays particular attention to sharing evaluation reports from operations and drilling projects and results of risk assessments within the whole organization. Andersen and Albrechtsen (ibid.) also points at technological solutions that can enable safe and efficient collection, visualization and distribution of real-time data as a resilient capability resource, including automated and autonomous systems. Related to real-time data as well as other forms of data and information, ensuring availability, integrity, reliability and confidentiality is critical.

Related to the resource group 'people', the case study points at the importance of relevant experience. Experience from the specific systems and environments one collaborate with, like offshore work experience for onshore support engineers, is advantageous. For instance, the case study showed that it is preferable that drilling engineers have experience from both offshore and onshore. Furthermore, it is indicated that the organization should courage its people to question the established and not take past successes as a guarantee for future success but instead constantly look for risks. Being curious about how the system and its environment functions may help people understand the system better and know what is the most important details to focus on in order to monitor and respond to risks

TOWARDS RESILIENCE-BASED SAFETY MANAGEMENT IN IO

In complex socio-technical systems, where adaptation and change is a prerequisite for operation, resilience-based safety management will contribute to and maintain safe and efficient operations. This is enabled by facilitating capabilities to adapt and react to anticipated and unanticipated events. As shown by a case study presented in this chapter, a resilience-based safety management approaches provide a conceptual framework that fits well with the dynamic and complex nature of well and drilling operations. In a management perspective, the key question thus becomes: how to develop a resilient organization?

Broadly speaking, safety management consists of two parts: administrating routine tasks (formal) and leading/guiding organizational processes (informal). Based on this division, it can be argued for two complementary approaches to refine a resilient organization.

First, capability resources should be identified, maintained and improved. Resilience is not only something that a system does; it is also inherent abilities in the system e.g. to be prepared to deal with unexpected events. Identifying resources that enable and maintain resilience capabilities for particular systems, as done in the presented case study, and maintain and improve these resources is one way to refine resilience in an organization. Training and developing adequate work processes would be one way to refine resilient capability resources.

Second, there is a need to develop methods and tools that makes it possible assess and control resilience, i.e. resilience-based safety management tools. Three promising developments are: resilience-based safety performance indicators; resilience-based operational risk assessments; and training and proactive emergency handling. These are described below.

Major accidents are rare events; it is thus hard to manage safety based on lagging (reactive) safety performance indicators. The data will be out-of-date and are often static interpretation of accidents (Wreathall, 2006). Leading indicators on the other hand will provide information such that "..actions can be taken in time to forestall an unacceptable change in one or more of the core outputs, or at least the management can anticipate and mitigate the adverse changes" (Wreathall 2011:67). Providing information about the status of the resilient performance of a system is a lead-

ing safety performance indicator, which should lead to interventions to manage and adjust the adaptive capacity (Woods, 2006). Two promising methods have been developed for this purpose: resilience based early warning indicators (Øien et al, 2010a; 2010b) and resilience analysis grid (RAG) (Hollnagel, 2011). An example of a RAG for integrated planning is shown in Apneseth et al. (unpubl.)

To strengthen the capability to anticipate future risks (both in term of threats and opportunities), incorporating resilience in risk assessments tools is promising. Resilience is per se not about risk, however it can be argued that improved resilience will reduce risk for thing going wrong. Resilience is not preoccupied with what can go wrong, but with succeeding under various conditions. Nevertheless, thinking in terms of resilience provides understandings that are valuable input to risk assessments. Hollnagel (unpubl.) shows how resilience can be utilized in risk assessments by considering how the organization and the safety management system will not be able to provide required functions, in particular that it will not be resilient (effective), in the face of accidents. The qualities of the resilient capabilities are pretty similar to secondary causes in a risk assessment perspective, and thus represent a possibility to incorporate qualities of the resilient system in risk assessments. Future developments should be to generate resilience-based analysis tools, e.g. check-lists for use in HAZOPs.

Integrated operations represent an opportunity to make emergency handling and preparedness more proactive by improved capabilities to monitor and anticipate what is going on, and thus mobilize responses at earlier stages (Tveiten et al., 2010). Often major accidents are characterized as unanticipated combinations of variations. For such situations one can experience to be unprepared to handle these unanticipated situations. A resilient system has to be both prepared and prepared to be unprepared (Pariés, 2011). As shown in the case study, improving capabilities to monitor and anticipate will strengthen the capability to cope with unanticipated changes at the sharp end. Also use of simulators to prepare crew members to cope with both anticipated and unanticipated events seems promising.

These, and other, conceptual ideas on resilience-based safety management needs to be established, calibrated and evaluated in close connection with practice

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REFERENCES

Andersen, S., & Albrechtsen, E. (2011). Resilience abilities in recent blowouts in the petroleum industry. In E. Hollnagel, E. Rigaud, & D. Besnard (Eds.), *Proceedings of the fourth Resilience Engineering Symposium.* Paris, France: Presses des Minnes.

Apneseth, K., Wahl, A. M., & Hollnagel, E. (in press). Measuring resilience in integrated planning. To be published. In Albrechtsen, E., & Besnard, D. (Eds.), *Interdiciplinary risk assessment in integrated operations*.

Chief Counsel. (2011). *Macondo. The Gulf oil disaster*. Chief Counsels's Report.

Farnham: Ashagate Øien, K., Massaiu, S., Tinmannsvik, R. K., & Størseth, F (2010a). *Development of early warning indicators based on Resilience Engineering.* Paper presented at PSAM10 (International Probabilistic Safety Assessment and Management Conference), 7–11 June 2010, Seattle, USA. Ø–11,

Grøtan, T. O., & Størseth, F. (2011). Integrated safety management based on organizational resilience. In *Proceedings of ESREL 2011*.

Hollnagel, E. (2011). Epilogue: RAG – The resilience analysis grid. In Hollnagel, E., Pariés, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice*. Farnham, UK: Ashgate.

Hollnagel, E. (Forthcoming). A resilience engineering approach to assess major accidents risk in IO. To be published. In Albrechtsen, E., & Besnard, D. (Eds.), *Interdisciplinary risk assessment in integrated operations*.

Hollnagel, E., Tveiten, C. K., & Albrechtsen, E. (2010). *Resilience engineering and integrated operations in the petroleum industry*. IO center white paper.

Hollnagel, E., Woods, D. D., & Leveson, N. (2006). *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Hopkins, A. (2009). *Failure to learn: The BP Texas City refinery disaster.* Sydney, Australi: CCH Australia.

K., Tinmannsvik, R. K., Massaiu, S., & Størseth, F. (2010b). *Development of new models and methods for the identification of early warning indicators*. SINTEF report no A16930.

Montara Commission of Inquiry. (2010). *Report of the Montara Commission of Inquiry.*

OLF. (2007). *HMS og Integrerte Operasjoner. Forbedringsmuligheter og nødvendige tiltak* [HSE and Integrated operations. Possible improvements and necessary measures]. Retrieved from www.olf.no

Pariol, J. (2011). Resilience and the ability to respond. In Hollnagel, E., Pariés, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice*. Farnham, UK: Ashgate.

PSA, Petroleum Safety Authority Norway. (2010). *Tilsynsaktivitet med Statoils planlegging av brønn 34/10-C-06A* (Gullfaks C) In Norwegian.

Rasmussen, J. (1997). Risk management in a dynamic society: A modeling problem. *Safety Science*, *27*(2-3), 183–213. doi:10.1016/S0925-7535(97)00052-0

Reason, J. (1997). *Managing the risks of organizational accidents*. Aldershot, UK: Ashgate.

Reiman, T., & Oedewald, P. (2009) *Evaluating safety-critical organizations deEmphasis on the nuclear industry.* Swedish Radiation Safety Authority report no 2009:12

Schiefloe, P. M., & Mauseth Vikland, K. (2005). *Årsaksanalyse etter Snorre A hendelsen 28.11.2004*. Stavanger, Norway: Statoil.

Statoil. (2010). *Intern granskningsrapport. Brønnhendelse på Gullfaks C* (04.11.10). In Norwegian [Internal investigation report, Gullfaks C].

Tinmannsvik, R. K., Albrechtsen, E., Bråtveit, M., Carlsen, I. M., Fylling, I., Hauge, S., … Øien, K. (2011). *Deepwater Horizon-ulykken: Årsaker, lærepunkter og forbedringstiltak for norsk sokkel.* [In Norwegian]. SINTEF report no A19148.

Turner, B. A., & Pidgeon, N. F. (1997). *Man-made disasters* (2nd ed.). London, UK: Butterworth-Heinemann.

Tveiten, C. K., Albrechtsen, E., Wærø, I., & Wahl, A. M. (2010). *Building resilience into emergency management*. Paper presented at Workingonsafety.net 2010.

Weick, K. E., & Sutcliffe, K. M. (2001). *Managing the unexpected*. San Francisco, CA: Jossey Bass.

Weltzien, A. (2011). *Resilience in well operations through use of collaboration technology.* Master thesis at NTNU.

Woods, D. D. (2005). Creating foresight: Lessons for enhancing resilience from Columbia. In Starbuck, W. H., & Farjoun, M. (Eds.), *Organization at the limit. Lessons from the Columbia disaster*. Oxford, UK: Blackwell Publishing.

Woods, D. D. (2006). Essential characteristics of resilience. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Woods, D. D., & Hollnagel, E. (2006). Prologue: Resilience engineering concepts. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Wreathall, J. (2006). Properties of resilient organizations: An initial view. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Wreathall, J. (2011). Monitoring – A critical ability in resilience engineering. In Hollnagel, E., Pariés, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice*.

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Chapter 22
Introducing IO in a Drilling Company: Towards a Resilient Organization and Informed Decision-Making?

Grethe Osborg Ose
Norwegian University of Science and Technology (NTNU), Institute for Industrial Economics and Technology Management/Norwegian Marine Technology Institute (MARINTEK), Norway

Trygve J. Steiro
Norwegian University of Science and Technology (NTNU), Institute for Production and Quality Engineering/SINTEF Technology and Society, Norway

ABSTRACT

The introduction of Integrated Operations (IO) in the offshore oil and gas industry makes distanced and distributed decision-making a growing part of normal work. Some functions have been transferred from offshore installations to onshore offices as a consequence of the technologies that have recently become available. The authors analyze whether the onshore organization is ready for increased responsibilities by increasing the resilience in its work patterns, since resilience is important for maintaining or increasing safety level compared to current operation, where personnel on board installations can observe the plant at first hand. This study has been performed as a case study of an onshore Support Center in a drilling company at the start of the process of using the Support Center. The establishment of the Support Center involved re-arranging the office arrangements to an open landscape for all offshore installation support personnel and grouping them according to disciplines. They also acquired new technology, including video conference equipment. Important findings are that developing resilience has to be followed through at all levels of the organization. Time and resources have to be made available when work practices change, providing the physical framework alone does not improve resilience. The study also offers a more detailed description of capability resilience and which aspects should be considered when developing resilience. The authors look at the status so far in the change process and also find areas that should be developed in order to increase resilience further.

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INTRODUCTION

"Integrated Operations" are commonly defined as *"*Characterized operational concept where information- and communication technology (ICT) and real-time data are explored to optimize the resources on the continental shelf (Norwegian Oil Industry Association (OLF), 2002)" or as *"*the use of information technology to change work processes to enable better decisions, to operate equipment and make decisions remotely and to move offshore functions onshore*"* (Parliamentary Bill no. 38, 2002). Another definition is that provided by CERA: *"*The vision of the Digital Oil Field is one where operators, partners, and service companies seek to take advantage of improved data and knowledge management, enhanced analytical tools, real-time systems, and more efficient business processes.*"* According to Edwards et al. (2010), this is the most frequently used current definition. As we can see, the emphasis is on technology and progress has primarily been technology-driven; a stepwise development from remote support, via remote monitoring to remote control of certain operations. The final step is to remote control of all operations (Johnsen et al., 2005) where more of the control of offshore installations is transferred from offshore installations to onshore operation centers. Edwards et al. (2010) describe three items that are central to recognizing operations as IO:

1. A move to a real-time or near real-time way of working.
2. The linking up of one or more remote sites or teams to work together.
3. A move to more multidisciplinary ways of working.

In this study, we analyze the physical arena of a Support Center as one such remote site working together with other sites or teams. We argue that organizational resilience is an important characteristic of such a team in order to utilize the competence in a team and to make better-informed and safer decisions. When functions are planned to be moved from offshore installations to offices onshore, the personnel in these offices must be ready and able to take them on in such a way that safe operation is maintained or increased The term "organizational resilience" means grouping the organization in a way that enables personnel to support and reassure each other, and it strengthens a decision by giving qualified personnel enough information to question it. Resilience will increase the safety of the decisions made (LaPorte and Consolini, 1991; Weick, 1987). Organizational resilience needs to be studied at this point because it becomes more and more important when changes lead to onshore control, with long distances between the actual operations offshore and the control of these operations performed by onshore personnel because the proximity to the operation that provide rich sources of feedback that involve almost all of the senses, enabling early detection of potential problems (Leveson, 2004) is lost. Although the industry believes that IO will lead to better and faster decision-making and improved safety, the literature has demonstrated that engineers and operators need to be physically close to each other (Hopkins, 2000). Even if several players can observe what is happening, mistakes in judgment and lack of communication and critical interpretation can lead to disasters, even if there seem to be resources available to create resilience (Snook, 2000).

We have analyzed this topic in one drilling company that started to work in an open office arrangement in which staff was located according to disciplines, and where meeting rooms with videoconference equipment and real-time data were available. Drilling companies are more dependent on short-term profits than the oil companies, and changes are therefore more rapidly put into effect. This made the drilling company a good choice for this study. We looked only at changes in the onshore company as they were in an early phase and presumably changes continue to take place

within the company rather than in the interface with the different oil and gas companies.

This study analyzes the consequences of a transformation from traditional office arrangements to an integrated Support Center, and examines whether the changes involved lead to a more resilient organization capable of better-informed decision-making. We developed a set of criteria for resilience by integrating relevant safety management literature with references in organizational learning, with the aim of contributing to the ongoing process of putting the term resilience into a more concrete form (Hollnagel and Woods, 2006). We discuss our findings in the case organization and use them to find areas in which the organization needs to develop resilience further.

THEORETICAL BASIS

High-reliability organizations, HROs, are capable of managing complex, demanding technologies and avoiding major failures while maintaining the ability to deal with periods of very high demand (Reason, 1997). Organizational resilience is the means adopted by such organizations to manage these demanding objectives. The term thus refers to a form of co-operation that enables the organization as a whole to perform more reliably than each individual operator would do (La Porte and Consolini, 1991; Weick, 1987).

Hollnagel, Woods and Leveson (2006) introduced the concept of "Resilience Engineering," which emphasizes building and cultivating resilience within the organization and its socio-technical system. Central aspects of resilience include instability and complexity. The concept assumes that both failure and success can be explained in the same way. Accidents can be understood as a wide variety of unexpected and uncontrolled events (Hollnagel, 2006), and they can therefore be explained by failure to adapt to these variations. Since these are inevitable, safety must be achieved by controlling performance rather than by constraining it. A resilient system must therefore possess three main qualities: it can respond to both regular and irregular threats in a robust, yet flexible manner; can monitor what is going on, including its own performance, in a flexible manner; finally, it can anticipate disruptions, pressure, and their consequences (Hollnagel et al., 2006).

In order to develop the concept, we introduce the concept of "communities of practice" from learning theory, and we suggest that in order to develop resilience, communities of practice need to be developed in areas where resilience is required. Organizations can be viewed as communities of communities, and in order to understand working and learning, we need to focus on the formation of change and on the communities in which work is done. Through the constant adoption of changed memberships and changing circumstances, communities of practice evolve as sites for innovation (Brown and Duguid, 1991). Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger et al., 2002). In this sense, a community of practice is not the same as an organizational unit, as a community of practice is the actual set of processes in which practices are discussed and where they evolve. Orr (1996) demonstrated that communities of practice are effective means of exchanging critical information and fostering learning in a hectic everyday environment. In this context, this means that learning is a matter of refining practices and ensuring new members are recruited. For organizations this means that learning sustains interconnected communities of practice through which an organization knows what it knows and thus becomes effective and valuable as an organization (Wenger, 1998).

Based on the safety management and organizational learning literature, we have developed

the concept of resilience further into practical arrangements and collaborative conditions to provide a deeper understanding and a set of criteria that can be used in further analyses of the capability of resilience.

Practical Arrangements for Resilient Organizations

1. Short-term efficiency and failure-free performance

HROs share the goal of completely avoiding serious operational failures. This goal rivals short-term efficiency as a primary operational objective, in which failure-free performance is a prerequisite for providing benefits. The operating challenge is twofold: to manage complex, demanding technologies, making sure to avoid major failures that could cripple the organization; at the same time to maintain the ability to deal with periods of high peak demand and production (LaPorte and Consolini, 1991).

2. Possibility for transparency

Rosness et al. (2000) suggest that prerequisites of what they call "organizational redundancy" include the ability of personnel to directly observe each other's work, overlapping competence, and overlapping tasks or responsibilities. LaPorte and Consolini (1991) also found that crew members with overlapping tasks and competences enabled them to correct errors. Wenger et al. (2002) state that an open dialog between inside and outside perspectives should be developed and Lave and Wenger (1991) argued that transparency is a crucial resource for increasing participation in communities of practice.

3. Technological and other physical opportunities to collaborate, space to collaborate

According to Wenger et al. (2002), both public and private community spaces ought to be developed and these should invite different levels of participation. LaPorte and Consolini (1991) also found that eye-to-eye contact and easy opportunities to communicate was essential.

4. Time and resources

LaPorte and Consolini (1991) state that ignoring the prerequisites for HROs and the costs and processes needed to ensure their existence is a source of major policy error and the roots of tragic remedies. Hollnagel and Woods (2006) also emphasized that resources are important for the ability of a system to respond rationally. They also find time to be an essential aspect of a resilient system. Time and resources are also implicitly included by Wenger et al. (2002) in order to use the required resources to develop communities of practice.

5. Providing support

Communities of practice must be provided with direct resources from the organization (Wenger et al., 2002).

Collaborative Conditions for Resilient Organizations

6. Anticipation

Hollnagel and Woods (2006) stated that knowing what to expect is crucial in building a resilient organization. Rosness et al. (2000) found capability and willingness to exchange information to be part of the cultural dimension for what they call "organizational redundancy." Traffic managers and information workers can keep each other updated by performing their tasks visibly and auditable in order to achieve a joint understanding of what is taking place (Heath and Luff, 1996).

7. Mindfulness

Hollnagel and Woods (2006) emphasized knowing what to look for as another quality of a resilient system, while Rosness et al. (2000) included providing feedback and consideration regarding decisions made by oneself or others in their cultural dimension. Here we also build on the work of Endsley on situational awareness (e.g. Endsley et al., 2003; Endsley, 1988). Situational awareness is defined as: "The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988: 4). Situational awareness can be regarded as a mental representation of the situation on which an operator bases his or her decisions. Situational awareness can therefore be separated into three levels; Level 1 - perception of the elements in the environment, Level 2 - comprehension of the current situation and, finally Level 3 - projection of future status. As we see it, attention is also closely linked to mindfulness. Mindfulness is defined as "a rich awareness of discriminatory detail" (Weick and Sutcliffe, 2007: 32). HROs observe the five principles of mindfulness: preoccupation with failure, reluctance to simplify, sensitivity to operations, commitment to resilience and deference to expertise. These principles can influence the design of processes and move the system toward the condition of mindfulness. The term is a combination of ongoing scrutiny of existing expectations, continuous refinement and differentiation of expectations based on newer experiences, a willingness and capability to invent new expectations that make sense of unexpected events, a more nuanced appreciation of context and ways to deal with it and the identification of new dimensions of context that improve foresight and current functioning (Weick and Sutcliffe, 2007). Hollnagel and Woods (2006) also point out that a resilient system must constantly be watchful and prepared to respond.

8. Response

Naturally, after knowing what to expect and knowing what to look for, a rational response follows if something goes wrong (Hollnagel and Woods, 2006). Rosness et al. (2000) refer to intervention to recover from errors. LaPorte and Consolini (1991) found that the culture in HROs supported interventions to recover from errors. They also found that there are different modes in the HROs where behavior changes according to demand, they are able to reconfigure spontaneously during demanding operating situations and crises. In periods with peak demand, they change from a hierarchical organization into a more flexible and resilient one where authority was based on competence rather than rank.

Safety knowledge is culturally mediated by forms of social participation, material working conditions, and the negotiated interpretations of action onsite (Gherardi and Nicolini, 2000). Safety knowledge is both dynamic and profoundly rooted in communities of practice. The authors point out that: "Safety is learned in conversations at the borders between communities of practice" (Gherardi and Nicolini, 2000: 12). In the conversations between the two communities, the communities tune into each other's discourses and codes of practice in terms of changes in meanings and concepts. Furthermore; "Knowing is a contested and negotiated phenomenon" (Gherardi and Nicolini, 2000: 12).

9. Legitimizing participation

A community of practice is a unique combination of three fundamental elements: a domain of knowledge that defines a set of issues; a community of people who care about this domain; and a shared practice that they are developing in order to be effective in their domain. The domain creates common ground and a sense of common identity. A well-defined domain legitimizes the

community by affirming its purpose and value to members and other stakeholders (Wenger et al., 2002).

10. Negotiating strategic context

Communities of practice form within and across business units and across organizational boundaries. Communities are formed where work is done and someone finds it worthwhile to spend resources on them. The probability that the communities that are important for the organization will be formed increases when these are seen as an important area that brings value to the organization (Wenger et al., 2002)

11. Create a rhythm for the community

The rhythm of the community is the strongest indicator of its liveliness. There are many rhythms in a community – the syncopation of familiar and exciting events, the frequency of private interactions, the ebb and flow of people from the sidelines into active participation, and the pace of the community's overall evolution. A combination of whole-community and small-group gatherings creates a balance between the thrill of exposure to new ideas and the comfort of more intimate relationships. A mix of idea-sharing fora and tool-building projects fosters both causal connection and direct community action. There is no right beat for all communities, and the beat is likely to change as the community evolves; but finding the right rhythm at each stage is the key to the development of a community (Wenger et al., 2002).

12. Organizational learning

The system must constantly update its knowledge, competence and resources by learning from successes and failures – its own as well as those of others (Hollnagel and Woods, 2006). Wenger et al. (2002) also emphasize the need for communities of practice to evolve and to combine familiarity and excitement. Argyris and Schön (1978) developed the terms "single-" and "double-loop learning." By single-loop-learning they mean instrumental learning that changes strategies of action or assumptions underlying strategies in ways that leave the values of a theory or action unchanged. In such learning episodes, a single feedback loop, mediated by organizational inquiry, connects detected error – that is, an outcome of action mismatched to expectations and therefore – to organizational strategies of action and their underlying assumptions. By double-loop learning, they mean learning that results in a change in values of theory-in-use, as well as in its strategies and assumptions. The double-loop refers to the two feedback loops that connect the observed effects of action with strategies and values served by strategies. Strategies and assumptions may change concurrently with, or as a consequence of, change in values. Double-loop learning may be carried out by individuals, when their inquiry leads to change the values or their theory-in-use, or by organizations, when individuals question their theories-in-use in such a way as to lead to change in the values of organizational theory-in-use.

These factors are discussed related to the case after the detailed description of the case in the following section. We have also included a discussion related to action and politics in the different sections in order to give more depth to the discussions. The theoretical foundation for these discussions is how organizations deal with inconsistent demands and how they tend to deviate in actions and statements to deal with it (Brunsson, 1989).

THE CASE

The case used in this chapter is a drilling company that established a Support Center based on the onshore support teams assigned to supporting its drilling rigs and floaters. Before the Support

Center was set up, the location of the onshore offices was somewhat arbitrary and not closely matched to ether the rig or the discipline of the employee. All rig support personnel were located on the same floor but in separate offices in the same area. After the establishment of the Support Center, the various disciplines were brought together in an open landscape in which all the support personnel were located. The relevant disciplines comprised operations, maintenance, drilling support, economy, quality, health, safety and environment (QHSE), and human resources (HR). Typically six persons are involved in the support of one installation, some of whom are assigned to two rigs or floaters.

This area is about 600 square meters and is the prime working area for 34 employees. In addition to standard office facilities, the area includes a room for videoconferences, two rooms with large screens for displaying data in real time. One of the rooms is also the emergency preparedness room. There are also two silent rooms in which staff can hold sensitive or private phone calls or meetings. The most significant change in working conditions in the Support Center does not concern technological changes, but rather changes in office arrangements.

One of the objectives was to increase transfers of experience between the rigs in order to perform the job more efficiently. The possibility of transferring functions from the offshore installations to the Center was also evaluated. A further goal was to reduce costs and manning on the basis of improved efficiency.

RESEARCH APPROACH

A project group of four researchers studied the Support Center and the company. Written material and oral presentations from the drilling company were used as background information before the interviews. Thirteen interviews were held with the 34 employees in the Support Center; each lasted for approximately an hour. At least three researchers were present at each interview, and it was decided that reports checked by the researchers involved were an adequate record of the data collected. The interviewees were selected from different disciplines in the Center. A longer interview was held with the manager responsible for implementing the Center, and finally a videoconference with the manager, his own immediate manager and an ICT manager. The interviews were conducted as open-ended interviews with an interview guide (Yin, 2004; Kvale, 1996). The areas covered centered on changes in the employees' personal work situation concerning cooperation, their experiences of the change process and any advantages and disadvantages they experienced, and possible scenarios for the future development of the Center. Additional questions to produce more concrete answers and make situations more specific were asked when possible. A memo including the most important findings was distributed to the drilling company for comments and suggestions in order to reinforce dialogue. Dijkstra (2006) questioned the notion that information on safety should be gathered only from safety personnel, and our data were gathered from all disciplines and could thus contribute to a wider perspective on safety and risk. The data collected were also discussed amongst the researchers as recommended by Yin (2004), for instance, in order to limit the individual researcher's interpretations of the data. The summary memo distributed to the company also gave it the opportunity to correct misunderstandings and wrong assumptions made by the researchers.

We developed a set of criteria aimed at making the concept of resilience more concrete and researchable. The criteria were developed after the interviews and memos had been sent out for verification. However, they were developed on the basis of theories and rather than on the actual interviews. Theories from both the area of organizational learning and organizational safety

were used because organizational learning has to be an important part of developing resilience and a great deal of research that we find relevant for the development of the concept has been done in this area. We argue that insight into the concept of resilience can be gained by incorporating the theory of organizational learning. Indeed, some of the criteria are equivalent in the two areas, as we have mentioned in the section "Theoretical Basis." As we see the establishment of the Support Center as a part of a change process, we have included findings both in the direction of increased and decreased resilience. We have also included characteristics in the case company that we find relevant for each criterion.

PRACTICAL ARRANGEMENTS FOR RESILIENCE IN THE CASE ORGANIZATION

The findings from the study are summarized according to the criteria outlined in the section "Theoretical Basis." This section contains the findings that are relevant to the first part of the list of criteria entitled "Practical arrangements for resilient organizations."

Short Term Efficiency and Failure-Free Performance

The case company has to live with short-term contracts, and it faces tough competition. It is thus unable to plan years ahead as it does not know what kind of contracts it will have even in the near future. Our company has recently passed through a downsizing process, because it lost contracts to competitors. This is the reality facing the company; it cannot afford to lose important contracts and cannot afford not to be ahead of developments in the industry. The Support Center and the use of videoconference equipment were established to gain a competitive advantage. The employees are very much aware of their vulnerability and are highly focused on the need to develop and be at the forefront of developments in order to survive.

The various disciplines first met to discuss what they could gain from establishing the Center. The main objectives were to find out how to make operations more efficient, identify tasks that could be moved from offshore and tasks that could be cut or modified, and how this would affect positions and procedures. All the personnel we talked to agreed that short-term savings and cost-cutting were the objectives of establishing the Center.

High health and safety standards are also important, since drilling is contract work in which health and safety criteria are regulated in the contracts. According to these factors, the drilling company has short-term efficiency as a goal. The company is used to adapting to the requirements of its customers and cooperating closely with them. It is also incorporating changes as a competitive advantage, thus demonstrating its ability to be pro-active. Major accidents such as blow-outs also have the potential to be very damaging for the company and could even put them out of business entirely.

Possibility for Transparency

The new office arrangements make it possible to observe the activities of others and to listen to what they are discussing and how they are reasoning. The informants pointed to greater access to informal information and knowledge of what other employees are doing. They also overlap in knowledge, and the Center as a whole possesses competence in all the areas necessary to support drilling on offshore installations. The following statement from a drilling engineer illustrates this fact:

All of us sitting down here are in different working situations. Two of the units are floaters and they have two people involved in supporting drilling; they are two at work at the same time. We are still sitting very much alone and are participating very

little in each other's problems. However, we do hear about them, and maybe we did not do that before. Before it was random and during lunch or so. It is more open now.

Some informants said that noise is a problem and that some personnel are not being selective and considerate regarding what they talk about loudly. This can be a problem in so far as some become annoyed and others may become extremely selective regarding which information they share with their colleagues. They do not want to be as annoying as they find some of their colleagues to be. This attitude could be illustrated by this statement from a drilling manager:

We mostly work as before. Mostly I notice there is more noise. If I have e-mails to write, I do that at home. There are always people passing by and asking questions. Sometimes you want peace and quiet to write, and that is not easy in the Center. It is enough that someone asks a simple question to distract you from your current thoughts.

The management was aware of this problem and emphasized that people should to speak up when they were annoyed, in order to enable management to deal with problems before they escalated. The awareness of noise in the Center also limits collaboration, because conversations need to be kept to a minimum.

TECHNOLOGICAL AND OTHER PHYSICAL OPPORTUNITIES TO COLLABORATE

Space to Collaborate

The physical office arrangements allow for better collaboration than before the Support Center was established. The videoconference equipment also improves collaboration with rig personnel because these also have a screen and can see the persons to whom they are talking. The informants are aware of the continuing need to go offshore in order to maintain personal contact with the offshore personnel, and they see this as a positive aspect. The office arrangement also makes it possible for office personnel to collaborate and have easy access to information on the screens in the collaboration rooms, which are mostly used for collaboration with other offices and rigs and rarely for internal collaboration between and within the teams in the Center.

Developing electronic cooperation in the oil and gas industry faces companies with technological challenges related to information security and firewalls between different companies. These challenges are dealt with as they occur, but one lesson to learn is that technology is not making electronic cooperation as easy as the most eager technologists have expected.

Time and Resources

Before the actual move into the Center, time and resources were spent on studying how the various disciplines could best work together. After the move, however, most of the informants regarded the available time as a problem. We observed that they are always in an extreme hurry running to meetings. They also work long hours. This can be illustrated with a statement from an economy manager:

There is a culture in the company for using people – we decide ourselves if we want to be here. Not all hours are on record, as it is not allowed to work as much as we do. We are on a fixed salary with overtime included.

The changes in the office arrangements also led to more tasks for some disciplines, making the time available for collaboration even more limited. The time saved by reducing travel thanks to the use of videoconferences was used to increase the number of tasks, and the possibilities of per-

sonnel reduction were considered. The management wished to save costs and man-hours and emphasized a rapid return on investments. This aim made time a scarce resource for the Support Center personnel. Spending time on discussions not directly relevant to the job at hand, knowing they have to work late to compensate, does not motivate personnel.

Providing Support

At the Center, part of the problem was the lack of support in using relatively simple equipment, like videoconference equipment, which created problems for the employees who were supposed to learn how to use it. A simple guide to using the videoconference equipment was also missing. This made the staff reluctant to use the equipment and schedule videoconferences because they knew there could be technical problems. A special competent user for the others to ask, a "super user," was appointed, but the other employees did not know who this was and thus they did not know whom to ask.

A summary of the findings concerning the practical arrangements is presented in Figure 1.

COLLABORATIVE CONDITIONS FOR RESILIENCE IN THE CASE ORGANIZATION

The findings from the study are summarized according to the criteria developed in the section "Theoretical basis." This section discusses the findings relevant to the second part of the list of criteria entitled "Collaborative conditions for resilient organizations."

Figure 1. Summary of findings in the case regarding the practical arrangements

Practical arrangements	**Finding in the case organization**
Short-term efficiency as goal and a failure-free performance	The drilling company works on short-term contracts, and depends on good relationships with its customers and good performance in health and safety to be selected for new contracts. A major accident could put it out of business.
Possibility for transparency	The office arrangements make it possible to observe the actions of others, even though time limits the possibilities to listen to others' reasoning. Noise is a problem. People have too much to do to pay much attention to the work of their colleagues.
Technological and other physical opportunities to collaborate, space to collaborate	There are technological and physical opportunities for collaboration. Technological difficulties regarding exchange of data due to different firewalls in different companies.
Time and resources	Time and resources were spent on analyzing possible effects of the Center ahead of the move. Time is a limiting factor for collaboration. Time is the scarcest resource.
Provision of support	Support has been somewhat limited regarding use of new technology.

Anticipation

The personnel in the Center are capable of performing others' tasks because there are several persons in different disciplines. The drilling company collaborates with various oil companies and is thus subject to different requirements in the contracts and offers from individual customers, which makes standardization of services and tasks inside the drilling company complex. Different contracts and practices for different costumers are making the overlap in knowledge difficult. Time to explain various possible ways of performing the operations, and perhaps even different terminology, is necessary even within the disciplines. A statement from one of the drilling engineers illustrates this:

It is too much to do every day, something always has to be put of until tomorrow. Serving the rig is always the first priority, then your own tasks, and thirdly the development of the Center.

We decided to look at practices developed in the Support Center, but of course the staff is also participating in communities of practices for the different rigs with their customers, and this community is the main focus of their attention, as it is closely related to company income and in the end, its survival. Flexibility and adjustments to its clients' systems is an important capability for the drilling company and enables them to be an integrated part of their customers' practices.

Due to some planned absences amongst personnel in the Support Center, the company decided to transfer some employees from Drilling to Quality, Health, Safety and Environment (QHSE). This could make the personnel more capable of understanding and taking on tasks from different groups, and may be a foundation for a community in Drilling to QHSE. However, drilling personnel were not replaced as they were removed. Instead the remaining personnel were allocated additional tasks, making them even busier. This can work against the formation of such a community of practice because there may not be time to maintain the relationships from the previous position.

The drilling personnel collaborate closely with their oil company customers, both onshore and offshore. The drilling program that is used as a basis for draining the field is developed by the oil company. The highest authority during drilling is a representative of the oil company offshore and he makes the final decisions regarding drilling activity and any deviations from the drilling program. Drilling data gathered from sensors and drilling mud are analyzed both on board the rig and in the shore office. Historical data from former wells are also studied by shore-based personnel in order to make the most informed decisions they can. In This drilling team uses the experience of both the oil company and the drilling company; they form a community of practice. What they do not use to its full potential is the drilling competence of the drilling company. In order to use this competence in the heat of drilling and the rapid need for decisions, drilling company personnel need to possess basic knowledge of the specifics of the well. There is no time for long explanations during drilling, because the costs of stopping drilling are formidable.

The HSEQ, HR and economy personnel, have largely used the potential of collaboration in the Center and they also collaborate more closely since its establishment. These are also the core disciplines in the Center and are usually not present at meetings with customers. They find that the Center makes it easier to help one another; the availability of the managers has increased and it is easier for new employees to become integrated into the organization.

Mindfulness

Some of our informants found that the Center gave them better insight in what their colleagues

were doing and that they gained an understanding both of their own discipline and regarding the tasks performed by the other disciplines. Others found that there was too little of this and that it would have increased their satisfaction in their work. There are also differences in attention between the disciplines and drilling is the discipline where they are in a position to provide feedback and consideration regarding the decisions made by others.

There is an emphasis on safety within the drilling company. However, in this area too, it is primarily responding to its clients' requirements as stated in the contract. An internal strategy and standard on safety could have been developed and that could have been a competitive advantage for the company; to have a deliberate and holistic approach to safety.

Response

During drilling, there are two persons with drilling competence; the operations manager and the drilling engineer. There is little willingness at this point in time for personnel to intrude on other colleagues' areas of expertise without being asked, but they say it is easier to ask their colleagues now than before. Different ways of working on the various rigs and with different operators also make the questioning of the work in other teams more complex.

The employees in the Center work in projects supporting different rigs and floaters. The deployment of personnel according to discipline, should move the organization towards a more matrix-oriented organization and make experience transfer within disciplines easier. However, the full potential could be utilized if they shared more common ground within each discipline or were better informed of the differences in standards, tools and specific characteristics of the different fields. They could also try to work at making different contracts more similar. According to one drilling engineer:

We have two identical floaters for the same operator and I thought that here we could support each other. But, then I discovered that the procedures were different due to differences in the contracts.

Developing a practice that is generic and can be used for all contracts may not be a realistic goal. Perhaps assigning some personnel to support or quality assurance for one rig in addition to the one they are already working on could be a more feasible solution. Perhaps the current team for a rig could be defined as the core team for this rig and additional personnel could be defined as the support team for the same rig. This would also give the organization access to more competence and resources if an emergency situation were to occur.

Legitimizing Participation

Before moving in to the Center, time and effort were put into analyzing potential benefits for the various disciplines and hence legitimizing participation in these discussions. After the actual move into the Center, however, our informants said that they considered that time spent on developing practices internally in the company is not time well spent. The focus should be on customers and their demands. There are also differences in the different disciplines in this area, where the disciplines that spend most time in the Center and work on the most similar tasks participate in developing communities of practices in their disciplines. Again, drilling is the discipline in which customer focus is sharpest and the development of an internal community has least legitimacy.

Managers pointed out that learning had already been achieved in the Center and that they could see the effects of the new office arrangements. It was expected to have been gained by the new office arrangements are; the managers did not mention the learning to require anything beyond that. This is only partially in agreement with our findings for some of the disciplines.

Negotiating Strategic Context

A strategic context for the establishment and development of communities of practices could not be identified; the objectives were short-term time savings and personnel reductions, even though one of the objectives was stated to be increased experience transfer. This can be illustrated by a statement from a drilling manager:

I was present at a meeting where the process was discussed, and I honestly believe that the management does not get what this is all about. Their focus was just on cutting personnel and they were determined to achieve this. Establishing the Center and cutting personnel were what they were concerned with. They thought it was as easy as that the Center itself would make the changes, and that is not the case at all.

Strategy development was left to its customers and the demands of the market, i.e. the decision to make changes in office arrangements came as a result of demands from an oil company. It was also noticed that the time given to implement changes before expecting a return on investments was extremely short. This also goes to show that experience transfer is regarded as important when policy is formed, but actual actions show that cutting of costs are more important.

In the process of deciding the placement of personnel and the specifications of the Support Center, the different disciplines provided inputs and discussed their tasks and how they could be solved better. There was no similar discussion concerning how cooperation between the various disciplines could be structured and improved to get the most benefit from of the changes. The offshore personnel were never involved in the decision process, even though an explicit intention was to transfer administrative tasks from offshore to onshore personnel.

Creation of a Rhythm

There is a rhythm of meetings and discussions in the Center. Regular meetings to discuss the experience gained has been established where everyone working there is present. Morning meetings with individual rigs are held every day with the oil company's onshore office and offshore. Some of the rigs use videoconferences and other phone meetings. All the personnel supporting the rig are present at these meetings. Other than that, the frequency, participants and content of meetings all differ in the individual disciplines.

The experts in drilling are frequently in meetings with their customers. One drilling engineer told us that in some weeks he had to be at as many as three meetings a day at the oil company's office. Another said that important meetings were often announced on the same day and also that meetings were often cancelled just before they were scheduled. The personnel in drilling are most involved in meetings with the oil companies, and they work closely together with them.

The HSEQ department also takes part in meetings before offshore personnel go offshore. These meetings have changed to a certain extent from regular meetings where they used to travel to the helicopter bases where the offshore personnel are gathered, to the use of videoconferencing. The economy department has meetings for all the floaters every fortnight, when they spend an hour looking at similarities and parallel issues. These meetings started since the move into the Center. The HR staff spends much of their day on the phone. They focus closely on offshore personnel and on obtaining replacements when someone is sick or absent for other reasons. They need to ensure that the number of persons offshore and their competence are always as specified in the contracts. They also follow up the personnel and have many administrative tasks.

Organizational Learning

One of the drilling engineers told us that their top manager had a slogan: "the only thing we know for sure is that there will be changes." This company is used to adapting to changes in demand and they are doing this successfully; otherwise, they would not still be in operation. Double-loop learning involves asking questions about the fundamental issues of the right things are being done. The drilling company does this, for instance, when Maintenance is exploring the possibility of offering onshore monitoring of drilling equipment as an additional service to customers. However, most of our informants said they were struggling to get everything done, but at a strategic level in the company they pay close attention to what is happening in the market and how they should adapt to changes. The establishment of the Center was a strategic decision and was implemented to be a competitive advantage. Even though one customer pushed the company into that decision, it did not have to implement it for all its customers, which would have been the cheapest short-term decision. The drilling company is also capable of implementing innovations made on one rig or floater to all the others on which it might be relevant. This shows that they are able to learn and implement changes according to experience.

A summary of the findings in the case regarding collaborative conditions is presented in Figure 2.

DISCUSSION

With the establishment of a Support Center as the first step towards increased control onshore, as described by Johnsen et al. (2005), the organization needs to develop increased resilience in order to be able to deal with its growing responsibilities, especially regarding safety. We have developed criteria for resilience and summarized the findings in our case organization related to these criteria. The criteria were divided into practical arrangements and collaborative conditions for resilience. Where practical arrangements were concerned, we found that the drilling company was operating in conditions that emphasize short-term efficiency and high safety standards. These conditions make the drilling company suitable for using the theory of high-reliability organizations. We also found that the technological and other physical arrangements did enable collaboration, but that time was a scarce resource in utilizing the full potential of collaboration. Operational transparency was also possible due to the office arrangement of an open landscape and placing the support personnel in the Support Center.

Regarding conditions for collaboration, we found that there were differences between the individual disciplines in the Center. The disciplines that did most of their work in the office collaborated most closely with their colleagues assigned to offshore installations. They developed internal communities of practice and were able to help each other and question decisions made by others. They were also able to spend time on collaboration and to exploit the competence in their field that was available in the Center.

The drilling discipline worked very closely with its customers. Differences in contracts and procedures complicated collaboration in drilling. The number of external meetings and the need for rapid decision-making further complicated internal collaboration. Differences in well characteristics also required basic knowledge about the well concerned for colleagues to be able to contribute, and this knowledge needs to be in place before the decisions are taken, because time is of the essence when drilling is under way. We found that drilling personnel formed communities of practice with their customers, and this was an important competitive advantage for the drilling company. We observed that in focusing too much on customer demands and on reducing costs, the company runs the risk of doing more of what they already are doing, with fewer persons. This can lead to single-loop learning as it is termed by

Figure 2. Summary of the findings in the case concerning the collaborative conditions

Collaborative conditions	Findings in the case organization
Anticipation	Individual members of staff is capable of doing colleagues tasks, since there are several people in the same disciplines, but this is somewhat challenging because the contracts are different. Focus on personnel reduction whenever possible, making them even busier. Drilling personnel collaborate closely with the oil companies, but there is not much internal collaboration. HSEQ, HR and Economy have utilized some of the potential of collaboration in the Center.
Mindfulness	Some find that the Center gives them greater insight. Others find there is too little transfer of experience. There are differences between disciplines. The attention on safety is mostly to satisfy customer, but an internal strategy and standard could be developed.
Response	For drilling, there are two persons for each rig or floater. They challenge and help each other as well as being part of the drilling team with the oil company. The placement of personnel according to discipline and working in projects is moving the company in the direction of a matrix organization. The potential could have been utilized even more. Personnel could have been assigned from other rigs to support functions.
Legitimizing participation	Before the move to the Center, work was done in the disciplines to find possible effects of the Center. Participation in meetings and discussions is not legitimized if it is not directly related to the tasks for which personnel are responsible. There are differences between disciplines as regards legitimate participation in developing communities of practice.
Negotiating strategic context	Developing internal practices is not of strategic importance in the sense that it is not given any resources to do so, even though experience transfer is claimed to be important. Expectation of rapid return on investment. Collaboration and how collaboration could be improved have not been discussed.
Creation of a rhythm	There are major differences between disciplines and their ways of working, how closely they collaborate with customers, number of external meetings, time spent on the phone, travel, etc. Some new meeting arenas are implemented after the move into the Center.
Organizational learning	Changes as a natural part of work. The strategic level in the organization is highly market-oriented and changes due to market changes are implemented. Little time to reflect on operative level. Innovations on one rig or floater can be implemented on others where relevant.

Argyris and Schön (1978), focusing on existing modes of operation. Furthermore, the drilling company needs to develop resilience designed by and for itself. A better understanding of the factors involved can be found by implementing the view of Brunsson (1989) on the difference between what is said for political reasons and what is actually done to get the job done. According to the objectives for the Support Center, there should be an increased experience transfer, but no time and resources were made available to let that happen. What followed the establishment of the Center were more tasks and personnel cuts. The tradition in the company of emphasizing external demands and regarding man-hours as an expenditure and not as a resource were obstacles

to such measures as involving more personnel than the core team in the drilling operations. However, there were few attempts to sugar coat the message from the management, which was very open about the objectives of establishing the Center, which were to save costs and to reduce the number of personnel serving each installation. However, the drilling company posesses a great deal of expertise, and this competence should be made more easily accessible to all the personnel in the drilling discipline. This could be achieved by putting time and resources into the formation of an internal community of practice that permit other personnel to contribute. We suggest that they either develop a full community of practice for all the drilling personnel or select some personnel assigned to other rigs as support personnel. This would also make the company more proactive and prepared if an emergency situation were to occur because they would have a larger team of experts that could quickly be brought up to speed on the actual situation.

We observed that activity was hectic and that time was a scarce resource. Better communication facilities can lead to more meetings and the risk of operation managers being too much involved in daily operations (Lauche and Krämer, 2005). Meetings of experts can be viewed as time-consuming and may meet with resistance, especially if it is hard for the experts to discern their contribution in the overall picture (Boyton and Fisher, 2005). In their description these authors offer the example of a virtuoso team of highly recognized experts with strong opinions, and a team manager who keep lose control on how each expert performed his particular tasks. But he also kept tight control of the weekly meeting, exercising strong discipline in order to ensure that the individual experts' views were properly put together (op. cit.). LaPorte and Consolini (1991) stress the importance of how tasks are sorted out by the different actors and how each is committed to enabling the operations to achieve high reliability. This is not to say that the drilling company in this study is not proactive, but rather about strengthening the proactive attributes and plan the use internal resources carefully.

Adopting the concept of a capability platform and viewing this platform as a stack, as described by Henderson et al. (2012), might help to explain our findings. The capability platform is described as a stack, in which technology solutions form the base of the platform with people, process and organizational elements making the upper layers. Organizations exist in a networked setting with heterogeneous resources. One key characteristic of the platform concept is that innovation and change often occur from outside to inside. Using this capability platform theory on our case company focuses attention on their customers and how they interact with them. Our case company is very customer-focused and willing to adapt to customer requirements, and this is also an important aspect of the capability platform, where capabilities are described as being developed in ecology as a virtual, increasingly global and network-based model. In light of this theory, we find that the drilling company is developing capabilities with its customers rather than within its own organization. For instance when it is adapting its technological systems, their processes and organization to individual customers, its own platform as a company is weakened and fragmented even though adjusting to customer requirements is an important competitive advantage for the company. The establishment of the Support Center is a step towards closer internal collaboration, but as we have found, it needs to be followed by internal processes. This is also an important input to the capability platform theory, which emphasizes interactions within companies as well as between companies.

DIRECTIONS FOR FUTURE RESEARCH

We studied a drilling company that had clear ideas about what it wished to achieve. The vision was to be able to align with the requirements of its petroleum company clients'. In the implementation of the changes involved, more emphasis was put on cost saving. The drilling company started with a wide perspective but may have narrowed its focus too much. It would still be interesting to see whether, on the basis of its experience, the drilling company, could explore further and take advantage of incorporating more disciplines into its integrated operations. Our study has focused only on the company itself, but studying the interface between the drilling company and a couple of oil and gas companies would be very interesting. The drilling company started early on piloting integrated operations. An overarching question could be how the company might mature and then continue to "earn and learn" as prescribed by Edwards et al. (2010).

CONCLUSION

Our question was whether our case company was prepared to take over tasks from offshore installations by making changes in its onshore office arrangements. In order to keep safety at least at its current level, they needed to build in resilience that would enable them to involve more qualified personnel and make more informed decisions. This could be a fruitful way to improve the resilience in the organization and simultaneously form an important common ground to create a community of drilling. We found that the changes in office arrangements, did lead to increased resilience, but their full potential was not realized. In order to develop resilience further, they must spend more time and resources on internal processes and doing so must be regarded as strategically important by the company. The company enjoys close collaboration with its customers and it contributed to decisions made by them. Developing shared competence in drilling would enable them to be more resilient and also make more informed decisions. The drilling company would benefit in the long run from spending time and resources on developing an internal drilling community to complement the communities they form with their customers and enable them to better exploit the competence that already exists in the company. They would also enhance their emergency preparedness.

We find that the criteria that we have developed concerning practical arrangements and collaborative conditions for resilience enable us to identify different aspects of resilience and also suggest areas into which efforts should be made in order to develop resilience further.

REFERENCES

Argyris, C., & Schön, D. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison- Wesley Pub.

Boyton, A., & Fisher, B. (2005). Hot teams in a cold climate. Norsk Hydro breaks the rules for a fast recovery in the face of adversity. In A. Boyton & B. Fisher (Eds.), *Virtuoso teams. Lessons from the teams that changed their worlds*. Financial Times, Prentice Hall. Pearson Education.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of practice: Toward a unified view of working, learning and innovation. *Organization Science*, *2*(1). doi:10.1287/orsc.2.1.40

Brunsson, N. (1989). *The organization of hypocricy. Talk, decisions and actions in organizations*. Chichester, UK: John Wiley & Sons.

Dijkstra, A. (2006). Safety management in airlines. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering concepts and precepts*. Hampshire, UK: Ashgate Publishing Ltd.

Edwards, T., Mydland, Ø., & Henriquez, A. (2010). The art of intelligent energy (iE)- Insights and lessons learned from the application of iE. SPE 128669, Paper presented at the SPE Intelligent Conference and Exhibition, Utrecht, The Netherlands, March 23-25 2010.

Endsley, M. R. (1988). Design and evaluation for situation awareness enhancement. *Proceedings of the Human Factors Society 32th Annual Meeting* (pp. 97-101). Santa Monica, CA: Human Factors Society.

Endsley, M. R., Bolté, B., & Jones, D. G. (2003). *Designing for situation awareness. An approach to user- centered design*. London, UK: Taylor Francis.

Gherardi, S., & Nicolini, D. (2000). The organizational learning of safety in communities of practice. *Journal of Management Inquiry*, *9*(1), 7–18. doi:10.1177/105649260091002

Heath, C., & Luff, P. (1996). Convergent activities: Line control and passenger information on the London Underground. In Engström, Y., & Middleton, D. (Eds.), *Cognition and communication at work*. New York, NY: Cambridge University Press.

Henderson, J., Hepsø, V., & Mydland, Ø. (2012). What is a capability platform approach to integrated operations? -An introduction to key concepts. In Rosendahl, T., & Hepsø, V. (Eds.), *Integrated operations in the oil and gas industry: Sustainability and capability development*. Hershey, PA: IGI Global.

Hollnagel, E., & Woods, D. D. (2006). Epilogue: Resilience engineering precepts. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering concepts and precepts*. Hampshire, UK: Ashgate Publishing Ltd.

Hopkins, A. (2000). *Lessons from Longford: The Esso gas plant explosion*. Sydney, Australia: CCH Australia Ltd.

Johnsen, S. O., Lundteigen, M. A., Fartum, H., & Monsen, J. (2005). *Identification and reduction of risks in remote operations of offshore oil and gas installations. ESREL 2005*. Poland: Tri-City.

Kvale, S. (1996). *Inter views: An introduction to qualitative research interviewing*. Thousand Oaks, CA: Sage Publications.

LaPorte, T. R., & Consolini, P. (1991). Working in theory but not in practice: Theoretical challenges in high reliability organizations. *Journal of Public Administration: Research and Theory*, *1*, 19–47.

Lauche, K., & Krämer, R. (2005). *Innovations in onshore drilling centres*. XII EAWOP Conference, Istanbul, May 12-15.

Lave, J., & Wenger, E. (1991). *Situated learning legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Leveson, N. A. (2004). New accident model for engineering safer systems. *Safety Science*, *42*, 237–270. doi:10.1016/S0925-7535(03)00047-X

Norwegian Oil Industry Association, OLF. (2002). Retrieved from www.olf.no

Orr, J. E. (1996). *Talking about machines: An ethnography of a modern job*. Ithaca, NY: Cornell University Press.

Reason, J. (1997). *Managing the risks of organizational accidents*. Aldershot, UK: Ashgate.

Rosness, R., Håkonsen, G., Steiro, T., & Tinmannsvik, R. K. (2000). *The vulnerable robustness of high reliability organisations: A case study report from an offshore oil production platform*. Paper presented at the 18th ESReDA seminar Risk Management and Human Reliability in Social Context Karlstad, Sweden, June 15 - 16, 2000.

Snook, S. C. (2000). *Friendly fire: The accidental shoot down of U.S. Black Hawks over Northern Iraq*. Princeton, NJ: Princeton University Press.

Stortingsmelding 7. (2001- 2002). *Om helse., miljø og sikkerhet i petroleumsvirksomheten. Arbeids- og Administrasjonsdepartementet* [Parliament Proposition number 7. 2001-2002, On Health Safety and Environment in the Petroleum Industry]. Retrieved from http://odin.dep.no/mod/norsk/dok/reg.publ/stmeld/002001-040012/hov001-bn.html

Weick, K. E. (1987). Organization culture as a source of high reliability. *California Management Review*, *29*, 116–136.

Weick, K. E., & Sutcliffe, K. M. (2007). *Managing the unexpected, resilient performance in an age of uncertainty* (2nd ed.). San Francisco, CA: John Wiley & Sons, Inc.

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems Thinker, 9*(5).

Wenger, E. C., McDermott, R., & Snyder, M. W. (2002). *Cultivating communities of practice*. Boston, MA: Harvard Business School Press.

Yin, R. (Ed.). (2004). *The case study anthology*. Thousand Oaks, CA: Sage Publications Inc.

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About the Contributors

Tom Rosendahl is Associate Professor in Market Communication at BI Norwegian Business School, Department of Leadership and Organizational Behaviour. He holds a PhD degree from the Department of Business Administration, School of Business, Gothenburg University, Sweden. His professional interests include marketing communication, cross-cultural communication, project communication, change management, and understanding the development in Integrated Operations. He has published widely and is the author/editor of 14 books. His latest books are entitled "Marketing in a Cross Disciplinary Perspective" (2008) and "Project Communication" (2010).

Vidar Hepsø holds a PhD in Social Anthropology from NTNU and is currently Principal Researcher/ Project Manager at Statoil R&D in Trondheim Norway. He is also Adjunct Professor at the NTNU Center for Integrated Operations in the Petroleum Industry. His main interests are related to new types of collaboration enabled by new information and communication technology (ICT) in general and in particular ICT-infrastructure development, capability platforms and collaboration technologies. The main work area the last 8-10 years has been within 'Integrated Operations' (IO) .Within this field of activities he is involved in both planning, execution, and evaluation of IO activities in Statoil in addition to being project manager and a resource for branch specific research and development of IO in both Norway and internationally.

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Eirik Albrechtsen is a Senior Research Scientist at SINTEF Technology and Society, department of safety research. He is also an Adjunct Associate Professor in Safety Management at the Norwegian University of Science and Technology (NTNU), department of industrial economics and technology management. He has a PhD in Safety Management from the same department. He has written several scientific publications on the implications from new technology and new organizational forms on risk and risk handling. He has been the project manager for the safety initiatives at the Center for Integrated Operations in the petroleum industry.

Andreas Al-Kinani holds a MSc. Degree in Petroleum Engineering of the Mining University in Leoben, Austria. He acts as a Managing Partner and Technical Director of myr:conn solutions. Andreas has been involved in numerous projects covering the whole petroleum system from the reservoir through the well head to the facilities and sales points. In his projects Andreas integrates data mining and artificial intelligence approaches with analytical and numerical petroleum engineering techniques.

He has implemented multiple reservoir and production performance surveillance systems for oil and gas companies worldwide and has developed several knowledge capturing solutions for production and reservoir engineering challenges. As an industry wide recognized expert for data mining in petroleum engineering and production workflow automation Andreas is holding related trainings and advising work in data mining and workflow automation for petroleum assets.

Theresa Baumgartner holds a Bachelor of Petroleum Engineering, a Master in Drilling Engineering and a Master in Petroleum Economics, all from the University of Leoben in Austria. During her studies she spent 6 months each at the UNSW in Sydney and the Hong Kong Polytechnic University. For her Master's thesis in corporation with myr:conn solutions, she formulated ideas on Bayesian networks for advisory systems, knowledge technology, and network system supporting knowledge sharing and collaboration. After internships with major oil companies in Austria, Germany, Norway, and Oman, she currently works at Booz & Company, a management consulting firm.

Alf Ove Braseth received the M. Sc. in Mechanical Engineering in 1992 at the Norwegian Institute of Technology (NTH). From 92 – 97 he worked as a Process Engineer in Norwegian oil company Norsk Hydro. From 97-00 he worked as a process engineer in the Norwegian oil company Saga Petroleum. From 00 to present he has worked as a Senior Research Scientist at the OECD Halden Reactor Project in the department of Operation Centres. He is one of the three inventors of the Information Rich Design concept for process control; and is currently developing large screen installations using the Information Rich Design both for offshore oil processes and now recently for the nuclear industry in Sweden and Finland.

Bernt A. Bremdal shares his time between academia and business. He is a Professor at Narvik University College in Norway and a Scientific Advisor within energy, media and technology. Dr. Bremdal's main research interest is related to smart systems and smart organizations. This includes artificial intelligence, decision support, knowledge management, and organizational learning. Over a span of 25 years he has worked with a number of businesses within oil, gas, electricity, manufacturing, metals, automotive, media, and defense. He headed the first team in GeoKnowledge that invented the GeoX explorationist tool which is used worldwide. He was also co-responsible for the development of ASAP which is used for analyzing safety of various offshore installations. He co-founded CognIT A.S. and MIRIAM A.S. The first company has had success with its web based process modeling and QA suite called Best Practice. This is now supplemented with the data-to-knowledge system called CognIT Knowledge Hub, also created by Dr. Bremdal. MIRIAM A.S is a rising star and offers tools for analyzing regularity of gas and oil flows.

Nihal Cakir holds a MSc. Degree in Business Administration of the University of Economics and Business in Vienna, Austria and she is studying Petroleum Engineering at the Mining University in Leoben, Austria. In her former studies she specialized in Change Management and Management Development. At myr:conn solutions, she is working as a Project Engineer.

Jan Ove Dagestad has Wide O&G industry experience, starting 20 years ago as field engineers moving into project and operations management for pumping, completion, and fluids services. For the last 12 years Jan Ove Dagestad has worked in business development and marketing and sales covering drilling and evaluation, later corporate marketing, as sales and business development director for BEACON, the Baker Hughes platform for Integrated Operations globally.

Jan Eivind Danielsen consults in the area Enterprise Architecture at the Scandinavian IT Consultancy company Bouvet ASA. His experience in the Oil and Gas Business and the field of Integrated Operations goes back to around year 2000. The main focus of his work is integrating ICT systems with the company management system to bring together information, roles, organizational entities, processes and compliance with rules, legislations and emerging best practices. As a former research fellow at NTNU in the field of applied creativity, the principles of innovation and knowledge creation have become integrated in the enterprise architecture approach.

Lars Kristian Due-Sørensen holds a Master of Science in Leadership & Organizational Psychology from BI Norwegian Business School, and a Bachelor's degree in Administration & Leadership from Oslo University College. Academic fields of interest include change management, training & development, employee motivation, and generally the psychological interplay within large organizations. Currently works as an HR Representative at GE Oil & Gas, and resides in the Oslo area, Norway.

Martin Eike holds a M.A. in Administration and Organization Theory from the University of Bergen and is Senior Consultant in Kongsberg Oil and Gas Technologies' business consulting unit. He has diverse experience from operational improvement projects and Integrated Operations initiatives in the E&P-industry, primarily working within the D&W-domain.

Asbjørn Egir is a Senior Advisor in the Upstream Oil & Gas Industry at Astra North, Stavanger Norway. His main areas of expertise are business process management (analysis, design, and implementation), change management, and organizational development. He also has experience as a project manager/team leader and facilitator. His most recent project was a pre-study of integrated planning and management system revitalization through business process analysis and redesign. Currently, he serves as the subject matter expert responsible for the multidisciplinary work method, Concurrent Design, in Astra North AS. Concurrent Design is real time interaction and collaboration between engineers, contractors, specialists, and customers enabled by process analysis, an integrated work environment and a prepared multi-disciplinary team.

Cathrine Filstad is Professor in Organizational Behaviour and Leadership at BI Norwegian School of Business. She holds a PhD in Organizational Learning and Knowledge Creation from Aarhus School of Business, Denmark. Her research focus is on learning and knowledge capabilities at work, including learning across boundaries and knowledge sharing in virtual teams. She has been included in research on communication technology and integrated operations in the Petroleums Industry where she has several scientific publications. She has substantial scientific publications within leadership, learning at work, newcomers learning processes, and strategic knowledge creation for innovative work and change. She has written five books and several book chapters on these topics. She also works closely with Norwe-

gian companies, holding presentations and consulting work, in addition to being part of several global academic communities."

Joanna Fraser has several years experience, starting 15 years ago as an offshore MWD engineer. Moved into engineering positions onshore within Integrated and Remote operations in 24/7 operations center, where last position was within BEACON GeoScience. Have since 2010 been responsible for operations of the Drilling and Evaluation BEACON center in Baker Hughes Norway.

José Adilson Tenório Gomes had a degree in Civil Engineering from UNICAMP in 1979. He completed his Master's in 1989 and his Ph.D. in 1998, also from UNICAMP. His areas of research were the numerical reservoir simulation and modeling of oil recovery by immiscible displacement. After graduation, he joined Petrobras as a Reservoir Engineer in the Campos Basin. In 1998 he became technical consultant. In 2001 he became the Marlim Asset Reservoir Manager. In 2004 completed an MBA in Assets Management and Partnerships. In 2006 assumed the position of Asset Manager. From 1998 to 2009 he served as Professor of Reservoir Engineering and Numerical Simulation disciplines at the University of North Fluminense. In 2010 took over the GIOp (Integrated Operations) implementation for Petrobras E & P. In 2011 has assumed the Reservoir Manager position for major development and production projects of the Petrobras E&P. His main areas of expertise include reservoir engineering, development and production projects, and integrated operations.

Ewoud Guldemond is a Senior Business Consultant Energy & Utilities at Atos Consulting The Netherlands. His specialty is in the field of organizational design, business process analysis & improvement, business - IT alignment, and international human resource management. Ewoud conducted a PhD research (Radboud University Nijmegen, The Netherlands) on organizational design of Integrated Operations (Smart Oil Fields) at a major independent oil company. He worked at different production locations of this major independent oil company worldwide. At these production locations, he interviewed technical specialists of Production Operations and Petroleum Engineering. Ewoud captured and analyzed data from interviews, documents and observations.He advised Senior Management of the Global Smart Oil Fields Team on employee engagement programs to effectively structure the organization and develop competencies of staff of its production locations within the Smart Oil Fields. His work resulted in a PhD thesis called "Collaborative Work Environments in Smart Oil Fields."

Kristin Halvorsen is a Research Scientist for the Norwegian Marine Technology Research Institute, MARINTEK, as well as pursuing a PhD in Language and Communication Studies at NTNU Social Research AS. She holds an M.A. in Interpersonal Communication from Ohio University and a Cand.Philol. in Applied Linguistics from Norwegian University of Science and Technology, NTNU. Her research interests comprise communicative strategies in cross-professional collaboration, interactional facilitation of teamwork, new forms of leadership, decision-making processes, and perspectives on contemporary work life. Before returning to academic life in 2009, she worked as an in-house communication consultant with a supplier of maintenance and modification services to the oil and gas industry.

Lisbeth Hansson holds a PhD in Maritime Safety from NTNU and is currently a researcher at SINTEF Trondheim Norway. She has been engaged in HSE and safety related issues within maritime and oil and

gas industry over the last 25 years. Integrated operations have been a main focus area for her research the last 8-10 years conducting projects for several oil and gas companies. Besides the HSE issues and IO, also work conditions, collaboration, and team work have been some key aspects within her work.

John C. Henderson is a Professor of Management at Boston University's School of Management and serves as the Director of the School's Institute for Global Work. He received his Ph.D. from the University of Texas at Austin. He is a noted researcher and executive educator with published papers appearing many journals. He is the co-author of *The Knowledge Engine*, which explores how effective leaders leverage the firm's knowledge assets. His co-authored paper with N. Venkatraman on strategic alignment of business and I/T strategies was selected by the *IBM Systems Journal* as a "turning point" article, one of the most influential papers on Information Technology strategy published by the Journal since 1962. Professor Henderson's current research focuses the economics of business platforms, global business architectures, and aligning business and IT strategies. He serves as a member of the board of Directors for ICEX and the science advisory board for *Natural Insights*.

Irene Lorentzen Hepsø holds a PhD in Sociology from NTNU – the Norwegian University of Science and Technology. She is currently Associate Professor in Organization and Management at Sør Trøndelag university college/ Trondheim Business School. Here she is Program Director for their Master of Science in Management of Technology. Dr Hepsø's main research interests are process-orientation, organizational development, and the role of ICT.

Erik Hollnagel is Professor at the University of Southern Denmark (DK), Industrial Safety Chair at MINES ParisTech (F), and Professor Emeritus at the University of Linköping (S). He has worked at universities, research centres, and industries in several countries and with problems from many domains including nuclear power generation, aerospace and aviation, software engineering, land-based traffic, and healthcare. His professional interests include industrial safety, resilience engineering, patient safety, accident investigation, and understanding large-scale socio-technical systems. He has published widely and is the author/editor of 19 books, including four books on resilience engineering, as well as a large number of papers and book chapters. The latest titles, from Ashgate, are "FRAM – The Functional Resonance Analysis Method," "Governance and Control of Financial Systems," "Resilience Engineering in Practice: A Guidebook," and "The ETTO Principle: Why Things that Go Right, Sometimes Go Wrong."

Even Ambros Holte is currently working as a Research Scientist for the Norwegian Marine Technology Research Institute – MARINTEK. Holding a Master's degree in Logistics Management from the University of Sydney (Institute of Transport Studies), he has for the past five years been performing research, development, and research-based advisory services within the maritime sector. With a particular interest for developing sustainable transport solutions and innovative practices for the maritime industry, he has during the past two years also been heavily involved in the area of integrated planning and logistics targeting the oil & gas industry. Living in Trondheim, Norway, Even has considerable experience as a project manager and has co-authored several conference papers.

Barry Jones is the Sales Director for Baker Hughes Norway. Past positions include Drilling & Evaluation Sales Manager & Coring Manager. Prior to joining Baker Hughes in 1997 he was Laboratory Manager with a major provider of Core Analysis, Chemistry, and PVT services in Norway.

Torbjørn Korsvold is a senior research scientist at SINTEF Technology and Society, Department of Industrial Management. He completed his Ph.D. in Organization and Management from the Institute of Industrial Economics at NTNU in 2002. Torbjørn has research practice from Stanford University and three years' experience as Head of Research within business and regional development at a regional research institute south of Oslo. In his research, he has especially worked with operative and participatory development processes focusing on integrated organizational- and technology development within construction-, process- and offshore related industry. As senior scientist in SINTEF since 2006, he has developed extensive experience from integrated operations in drilling and well in the Norwegian petroleum industry with focus on efficiency and safety issues related to new work processes and team based work forms based on available advanced decision support systems including analysis tools (incl. high capacity telemetry while drilling) and diagnostic systems.

Gunnar M. Lamvik is Ph.D. in Social Anthropology, NTNU, and now a Senior Researcher at SINTEF Technology and society, in Trondheim, Norway. Lamvik has over the years been involved in a long range of R&D projects inside maritime and Oil and Gas industry. Both the shipping and offshore industry in South East Asia, Gulf of Mexico and the North Sea (UK and Norway) has been analyzed in the projects. The topics covered in the projects have been pivoting around the relationship between: cultural differences, work practice, and safety.

Sjur Larsen is a researcher at NTNU Social Research, which a fully owned company of the Norwegian University of Science and Technology (NTNU). He is a Doctoral candidate in Sociology at NTNU, writing a Doctoral dissertation on distributed teamwork. Larsen is a researcher in the Center for Integrated Operations in the Petroleum Industry at NTNU, conducting research on new teamwork, leadership, and capability development practices in the oil and gas industry. He is an active contributor in the Master of Management program at NTNU, heading the "Collaboration, Social Networks, and New Media" course within the Master of Management program. He is also involved in research collaborations between Norway and Qatar, as project manager of the "Virtual Collaboration and Integrated Operations" project in the Norwegian aluminium company Hydro's R&D program at the Qatar Science and Technology Park (QSTP) in Doha, Qatar.

Claudio Benevenuto de Campos Lima holds a degree in Chemical Engineering from the University of Minas Gerais (1986) and after 2010 he is a Master student at the University of North Fluminense. His areas of research are management systems and enterprise strategy. He joined Petrobras in 1987 as a formation evaluation engineer in Espirito Santo Basin. After 1991, he was dedicated to well construction in Campos Basin, as a company man and well designer in drilling and completion projects. He was ahead of the smartfield implementation of the Integrated Digital Mangement (GeDIg) Pilot at Carapeba Field. In 2001, he became the Lifting and Flow Assurance Manager in Campos Basin Northeast Asset. In 2004, he assumed the Automation and Process Integration Department in Campos Basin. He coordinated the remote control implementation in more than 10 platforms in Campos Basin. After 2009, he coordinates

the Integrated Operations Pilot in Tupi Field and he is ahead of the Integrated Operations (GIOp) project implementation in Santos Basin. His main areas of expertise include formation evaluation, completion and drilling, lifting and flow assurance, automation, and integrated operations.

Bjørn-Emil Madsen holds a Master's degree in Psychology from NTNU and is currently a researcher at SINTEF Trondheim Norway. He has been engaged in safety and efficiency improvement actions issues in the Norwegian oil and gas industry the last 12 years, with a focus on individual and collective learning processes. Issues concerning the implementation of Integrated Operations have been a main interest the last 8 years. Within the MTO-paradigm, Madsen have had a special interest in the socio-psychological aspects of both the implementation process and the challenges of collaborative work.

Berit Moltu holds a PhD (2005) in Organizational Change and Management from NTNU, HF-faculty, Department of Interdisiplinary Cultural Studies. She was originally educated as an engineer in Petroleumtechnology at NTH, Trondheim, and has additional education in Organisational Worklife Studies. She has published both national and international on Employees Participation, the origin and translation of the Management Concept of the 90'ies BPR (Business Process reengineering), on Anthropological Methods and in Science and Technology Studies. She has participated in both national and internationally research projects such as PAKT (Program on Applied Coordination Technology, a national multidisciplinary program on ICT and collaboration) and PRECEPT (Process Re-Engineering in Europe: Choice, People and Technology, an EU project), amongst others. She has been a senior Researcher and Project leader in SINTEF, Trondheim for 5 years, and before that 5 years as a researcher at Science and Technology Studies at NTNU, Trondheim. She now works for Statoil in Stavanger on IO and HSE (Organization Safety and Human Factors).

Øyvind Mydland is the Director of Stepchange Global Limited, he has extensive experience within Integrated Operations (IO). Øyvind Mydland has been involved in the integrated operations movement since 2000. He is an engineer in computer and automation and he arrived at the scene with a background in engineering, information technology and business development spanning over 20 years. In January 2000 he founded Stepchange, a dedicated IO consultancy and advisory company and has advised Statoil, BP, Talisman, Eni and other major companies in the oilm& gas industry on their IO strategies and programmes. Stepchange Global is a team that specialises in assisting companies to fully comprehend and develop their capabilities and the potential efficiencies that integrated operations enables.

Grethe Osborg Ose has the degree of Master in Science from 1997 in the field of Health, Safety, and Environment from NTNU, her specialty being Safety Management. After graduation, she started working as a Research Engineer at the Norwegian Marine Research Institute (MARINTEK) and here she worked with training of seafarers in safety, mostly by participating in the development of computer based training modules to be used on board ships. She also worked with knowledge management and changing competence requirements in shipping. Later, she developed more competence in organizational development and change processes and the last years she has worked with change projects related to Man, Technology, and Organization (MTO), mostly in the oil and gas industry.

Grete Rindahl is a principal scientist at the Institute for Energy Technology (IFE) in Norway. Her affiliation is with the Sector for Man-Technology- Organization and Safety (MTO), Section for Human-

Centred Technologies. Her research background is both from nuclear and petroleum. In nuclear she has been specializing on decommissioning related issues, in petroleum on integrated operations (IO). She has been leading research projects within IO for several years, focusing on issues related to visualisation and collaboration technology, IO training, and IO teamwork. At present she is project manager of the project "IO Teamwork and Capabilities" at the IO Center (www.iocenter.no). She holds a M. Sc. in Applied Mathematics from the University of Tromsø.

Lone Sletbakk Ramstad is working as a Senior Research Scientist for the Norwegian Marine Technology Research Institute, MARINTEK. She is also pursuing a PhD at NTNU, Industrial Economics and Technology Management. She holds a Master of Science degree in Civil Engineering from Norwegian University of Science and Technology, NTNU. The past three years her research has been within the field of integrated operations in offshore and maritime industry, especially focusing on integrated planning. Her research interests are in organizational learning, cross disciplinary collaboration, organizational culture, and collaboration technology. Lone has managerial experience from both the private and public sector. She is currently project manager for " IO 2 Integrated Planning and Logistics" within the Center for Integrated Operations in the Petroleum Industry (IO Center) and project lead for MARINTEK within the EU research project FInest focusing on future internet solutions in transport and logistics.

Anders Rindal holds a Master's degree in Technology Management from Trondheim Business School (TBS), and is currently working as a business intelligence consultant at Affecto Norway. He has been engaged in how information technology and information management can help organizations take better decisions and work more effectively. As he is early in his career, he continues to expand his fields of experience.

Erik Rolland, Ph.D., is Professor of Management within the School of Engineering at the University of California - Merced. Erik has previously been on the faculty of the Anderson Graduate School of Management at University of California-Riverside, the Fisher School of Business at the Ohio State University, and a visiting Professor with the Antai School of Management & Economics at the Shanghai Jiaotong University. Erik's research embodies a broad range of management and engineering areas, electronic commerce, service science, and modeling of complex technology and management problems, and has been published in journals such as *Operations Research*, *European Journal of Operational Research*, *Decision Sciences*, and many others.

Sizarta Sarshar is a Research Scientist at Institute for Energy Technology (IFE) who works in the Software Engineering department. He has been working on several research projects on error propagation and common cause failures in computer science, and has in recent years also been working on technology and software aspects for visualization of Health, Safety and Environmental related hazards within integrated operations. He holds a MSc in Computer Science with focus on safety critical systems and works now on his PhD. The topic of his work is on decision making in integrated operation collaboration processes with focus on visualizing safety hazard indicators in planning of offshore operations for prevention of major accidents.

Kari Skarholt is Cand.Polit in Sociology from NTNU, Norway. She is currently Senior Researcher at SINTEF in Trondheim, Norway. She has earlier been working at Statoil R&D as a Senior Researcher for 18 years. Kari's main interests are: safety management and work practice in the petroleum industry, organizational learning and team work. Integrated Operations (IO) has been her main research area for the last seven years, exploring on; safety management and standardization, new work practices, leadership and trust.

Ann Britt Skjerve holds a MA (Psychology) and a Ph.D. (Psychology from the University of Copenhagen. She has been employed at the Institute for Energy Technology since 1997, currently as Principal Scientist and as Deputy Division Manager in the Industrial Psychology department. Ann Britt has been engaged in research projects within the domains of nuclear power, petroleum, and transport as a human factors expert. Her special areas of interests include teamwork in co-located and distributed teams, teamwork training, development of tools and work practices to promote safe operation, and usability evaluation.

Tygve Jakobsen Steiro holds a Master degree in Organizational Psychology from the Norwegian University of Science and Technology (NTNU) in 1997. He has since then worked for various organizations such as the Norwegian National Road Administration, SINTEF, The Municipality of Trondheim and The Royal Norwegian Air Force Academy. He is currently conducting a PhD study at Institute for Production and Quality Engineering at NTNU. He is also working part time for SINTEF. The theme of the PhD study is steering of dynamic business processes. His interests are linked to leadership, interaction in organizations, change, communication, motivation, and organizational learning.

Michael Stundner holds a MSc. Degree in Petroleum Engineering of the Mining University Leoben, Austria (Graduation 1988). Michael has 20+ years of experience in the oil & gas industry as reservoir & production professional, inventor, and entrepreneur. Since 1997, Michael has been developing Artificial Intelligence solutions & technology which has been successfully been implemented in Digital Oilfield projects around the globe, including Norway, Mexico, Brazil & Kuwait. Between 2004 and 2010 he worked as Global Product & Marketing Manager for SIS after he sold his company Decision Team - Software GmbH to Schlumberger. His current position is Managing Partner & Senior Consultant of myr:conn solutions GmbH developing innovative Cloud Computing solutions. He is appreciated by clients as trusted advisor for enhancing production operations using workflow automation, collaborative environments, and advisory tools. He has been presenting his work in numerous papers, industry conferences, workshops, and forums. His work led to several patents.

Dominic Taylor has worked in the Integrated Operations and Digital Oilfield domain for the last 10 years in roles ranging from strategy development to project delivery in the industry's leading programmes. Author of a number of papers on Integrated Operations and collaborative working, Dominic is a regular contributor on the topic of transformation in the Oil and Gas industry and works with organisations to create pragmatic and value-driven approaches to realising the Integrated Operations vision. He is a Managing Consultant in Wipro's Oil and Gas group and has a leadership role in their Digital Oilfield and Collaborative Environment solutions.

Glenn-Egil Torgersen is Associate Professor of Education at the Norwegian Defence University College, Akershus Fortress in Oslo, Norway. He is also a Visiting Senior Researcher in Training and Industrial Psychology at the Institute for Energy Technology (IFE Halden). He holds a PhD in Psychology and 1. competence (similarity to PhD) in Pedagogy. His primary areas of research include cognitive psychology, multimedia learning, interaction and communication in digital visual environment, and structures of basic pedagogical view in complex and international risk organizations. His ongoing research is to develop research-based observational factors and training methods for effective interaction and video conferencing in complex situations and mosaic meetings (split screens), both in terms of communication, technology use, management and team processes. Dr. Torgersen has been published in different national and international books (e.g. "Military Pedagogies. And why they matters" [Sense Publishers, 2009]), and classified and unclassified reports. His theoretical and empirical work also appears officially and aggregately in national educational policy documents of several public agencies in Norway. He serves on several advisory and editorial panels, and reviews manuscript submissions for national and international journals and books.

Hans Jørgen Ulsund (1985) attended BI Norwegian Business School from 2006-2011 and graduated with a Master's degree in Business and Economics. During the two final years he specialized in leadership and organisational psychology, particularly focusing on organizational change and change management. Today he works as a Consultant at Vitari, a Norwegian IT-company.

Kristian Waldal holds a Master's degree within Technology Management from TBS (Trondheim Business School). He is is currently working as a Business Consultant at Deltek, with implementation of the Deltek Maconomy ERP-system in Professional Service Organizations. He has been engaged in how information technology and information management can help organizations take better decisions and work more effectively. As he is early in his career, he continues to expand his fields of experience.

Audun Weltzien is a Risk Assessment Consultant at Rambøll in Gothenburg, Sweden. He holds a Master of Science in Safety Management at the Norwegian University of Science and Technology (NTNU), department of industrial economics and technology management. He received his Master degree in 2011 for his Master thesis "Resilience in Well Operations through Use of Collaboration Technology," which is based on a case study of an onshore drilling support center. His thesis has been awarded with Tryg insurance company's best safety management master thesis award in 2011. He is currently working with risk analyses and safety management consultancy in infrastructure and construction projects within the transport, building, and energy sector.

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Compilation of References

Abrams, L. C., Cross, R., Lesser, E., & Levin, D. Z. (2003). Nurturing interpersonal trust in knowledge-sharing networks. *The Academy of Management Executive*, *17*(4), 64–77. doi:10.5465/AME.2003.11851845

Adefulu, Y. (2010, March). *SPE-128713: Enhancing asset performance: How can the benefits of collaborative work environments be effectively measured?* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Alberts, D. S., & Hayes, R. E. (2003). *Power to the edge command control in the information age*. Washington, DC: CCRP Publication Service. Retrieved September 20, 2009, from http://www.dodccrp.org/files/Alberts_Power.pdf

Alberts, D. S., Garstka, J. J., & Stein, F. P. (1999). *Network centric warfare: Developing and leveraging information superiority*, 2nd ed. Washington, DC: CCCR Publication series, National Defence University.

Alberts, D. S., & Hayes, R. E. (2003). *Power to the edge, command and control in the information age*. CCRP Publication Series.

Albrechtsen, E., Grøtan, T. O., Skarholt, K., & Hermundsgård, M. (Forthcoming). *Risk governance: pre-assessment of Integrated Operations. Concepts and cases, possibilities and threats.* SINTEF draft report, to be published on www.sintef.no/rio

Anand, N., & Daft, R. L. (2007). What is the right organization design? *Organizational Dynamics*, *36*(4). doi:10.1016/j.orgdyn.2007.06.001

Andersen, S., & Albrechtsen, E. (2011). Resilience abilities in recent blowouts in the petroleum industry. In E. Hollnagel, E. Rigaud, & D. Besnard (Eds.), *Proceedings of the fourth Resilience Engineering Symposium.* Paris, France: Presses des Minnes.

Andersson, O., & Rollenhagen, C. (2002). The MTO concept and organizational learning at Forsmark NPP, Sweden. Presentation held at the IAEA International Conference on Safety Culture in Nuclear Installations, Rio de Janeiro, Brazil, 2-6 December 2002.

Andresen, G., Rosness, R., & Sætre, P. O. (2008). Improvisasjon - tabu og nødvendighet (Improvisation – tabu and necessity). In R. Tinmannsvik (Ed.), Robust arbeidspraksis - hvorfor skjer det ikke flere ulykker på sokkelen? (Robust work practice – why doesn't more accidents occur on the continental shelf?) Trondheim, Norway: Tapir Akademisk forlag.

Andres, H. P. (2002). A comparison of face-to-face and virtual software development teams. *Team Performance Management: An International Journal*, *8*(1/2), 39–48. doi:10.1108/13527590210425077

Ansoff, I. (1979). *Strategic management*. London, UK: MacMillan.

Antonsen, S., Skarholt, K., & Ringstad, A. J. (2011). (in press). The role of standardization in safety management. *Safety Science*, (Special Issue). doi:10.1016/j.ssci.2011.11.001

Apache. (2011). *Web server.* Retrieved from http://httpd.apache.org/

Apneseth, K., Wahl, A. M., & Hollnagel, E. (in press). Measuring resilience in integrated planning. To be published. In Albrechtsen, E., & Besnard, D. (Eds.), *Interdiciplinary risk assessment in integrated operations*.

Ardichvili, A., Page, V., & Wentling, T. (2003). Motivation and barriers to participation in virtual knowledge-sharing communities of practice. *Journal of Knowledge Management*, *7*(1), 64–77. doi:10.1108/13673270310463626

Argyris, C., & Schön, D. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison- Wesley Pub.

Artman, H. (2000). Team situation assessment and information distribution. *Ergonomics*, *43*, 1111–1128. doi:10.1080/00140130050084905

Asch, S. (1952). *Social psychology*. Englewood Cliffs, NJ: Prentice-Hall. doi:10.1037/10025-000

Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: Regional innovation systems. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

Assmann, R., & Hillestad, T. (2008). Forutsetninger og betingelser. [Conditions] In Assmann, R. (Ed.), *Teamorganisering. Veien til mer fleksible organisasjonsformer* [Team organization. The way a head for more flexible forms of organization]. Bergen, Norway: Fagbokforlaget.

Aviolo, B. J., & Yammarino, F. J. (Eds.). (2003). *Transformational and charismatic leadership: The road ahead*. New York, NY: Elsevier.

Avoilo, B. J. (2005). *Leadership development in balance: Made/born*. Mahwah, NJ: Erlbaum.

Baan, A., & Maznevski, M. (2008). Training for virtual collaboration: Beyond technology competences. In Nemiro, J., Beyerlein, M. M., Bradley, L., & Beyerlein, S. (Eds.), *The handbook of high performance virtual teams: A toolkit for collaborating across boundaries*. San Francisco, CA: Jossey-Bass.

Babadagli, T. (2005, June), *SPE-93884: Mature field development – A review.* Paper presented at the SPE Europec/EAGE Annual Conference, Madrid, Spain.

Bailey, B. (2006). *Getting the complete picture with usability testing*. Retrieved December 26, 2011, from http://www.usability.gov/articles/newsletter/pubs/030106news.html

Banfield, E. C. (1959). Ends and means in planning. *International Social Science Journal*, *11*(3), 361–368.

Barber, A., Shippen, M., Barua, S., Velázquez, J., Hernández, A., & Klumpen, H. (2007). Optimizing production from reservoir to process plant. *Schlumberger Oilfield Review*, *19*(4), 18–29.

Baron, R. (2005). So right it's wrong: Groupthink and the ubiquitous nature of polarized group decision making. *Advances in Experimental Social Psychology*, *37*, 219–253. doi:10.1016/S0065-2601(05)37004-3

Barsa, M., & Dana, D. A. (2011). Reconceptualizing NEPA to avoid the next preventable disaster. *Boston College Environmental Affairs Law Review, 38*(2). Retrieved from hhtp://lawdigitalcommons.bc.edu/ealr/vol38/iss2/2

Bartram, M. A., & Wood, T. (2009, May). *OTC-20006: Future vision: The next revolution in production operations.* Paper presented at the 2009 Offshore Technology Conference, Houston, Texas, USA.

Bass, B. M., & Avioli, B. J. (1994). *Improving organizational effectiveness through transformational leadership*. Thousand Oaks, CA: Sage.

Bate, P., Kahn, R., & Pye, A. (2000). Towards a culturally sensitive approach to organizational structuring: Where organization design meets organization development. *Organization Science*, *11*, 197–211. doi:10.1287/orsc.11.2.197.12509

Bayerl, P. S., Lauche, K., Badke-Schaub, P., & Sawaryn, S. (2008, February). *SPE-112104: Successful implementation of collaborative environments: Human factors and implications.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Bechky, B. A. (2003). Sharing meaning across occupational communities: The transformation of understanding on a production floor. *Organization Science*, *14*(3), 312–330. doi:10.1287/orsc.14.3.312.15162

Beck, U. (2000). *What is globalization?*Cambridge, UK: Polity Press.

Beer, M., Eisenstat, R. A., & Spector, B. (1990). Why change programs don't produce change. *Harvard Business Review, November.*

Beer, M., & Nohria, N. (Eds.). (2000). *Breaking the code of change*. Boston, MA: Harvard Business School.

Behounek, M. (2003). Five elements for successful knowledge management. *Journal of Canadian Petroleum Technology*, April, 12-14.

Belbin, M. (2010). *The management of teams: Why they succeed or fail* (3rd ed.). Oxford, UK: Butterworth-Heinemann.

Bellinger, G., Castro, D., & Mills, A. (2004). Data, information, knowledge, and wisdom. *Systems Thinking*. Retrieved December 16, 2011 from http://www.systems-thinking.org/dikw/dikw.htm

Benford, S., Greenhalgh, C., Rodden, T., & Pycock, J. (2001). Collaborative virtual environments. *Communications of the ACM*, *44*(7), 79–85. doi:10.1145/379300.379322

Bennis, W. (2000). Leadership of change. In Beer, M., & Nohria, N. (Eds.), *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Berg, B. L. (2009). *Qualitative research methods for the social sciences* (7th ed.). Boston, MA: Allyn & Bacon.

Beyerlin, M., & Harris, C. (2004). *Guiding the journey to collaborative work systems: A strategic design workbook*. San Francisco, CA: Jossey-Bass/ Pfeiffer.

Bijker, W. E., Hughes, T. P., & Pinch, T. (1987). *The social construction of technological systems*. Cambridge, MA: The MIT Press.

Birkinshaw, J. (2000). Network relationships inside and outside the firm, and the development of capabilities. In *J. Birkinshaw & P. Hagström (2000). The flexible firm: Capability management in network organizations*. Oxford, UK: Oxford University Press.

Blackler, F. (2004). Knowledge, knowledge work and organizations: An overview and interpretation. In Starkey, K., Tempest, S., & McKinlay, A. (Eds.), *How organizations learn. Managing the search for knowledge* (pp. 339–362). London, UK: Thompson Learning. doi:10.1177/017084069501600605

Blake, C. T., & Rapanotti, L. (2004). Usability evaluation of distributed groupware in distance learning. In Y. Akpinar (Ed.), *Proceedings of the Fifth International Conference on Information Technology Based Higher Education and Training* (pp. 500–504). New York, NY: IEEE.

Bloedorn, E., & Wnek, I. (1995). Constructive induction-based learning agents: An architecture and preliminary experiments. *First International Workshop on Intelligent Adaptive Systems* (pp. 38-51). Melbourne Beach, Florida, US.

Böhn, K. (2008). *KnowledgeCraft proposal preparation*. Workshop FHG AIAIS, Bonn, 31.1.2008

Bolman, L. G., & Deal, T. E. (2003). *Reframing organizations: Artistry, choice, and leadership* (3rd ed., pp. 367–408). San Francisco, CA: Jossey-Bass.

Boudreau, K., & Hagiu, A. (2005). Platform rules: Multi-sided platforms as regulators. In Gawer, A. (Ed.), *Platforms, markets and innovation* (pp. 163–191). London, UK: Edward Elgar.

Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. Cambridge, MA: MIT Press.

Boyton, A., & Fisher, B. (2005). Hot teams in a cold climate. Norsk Hydro breaks the rules for a fast recovery in the face of adversity. In A. Boyton & B. Fisher (Eds.), *Virtuoso teams. Lessons from the teams that changed their worlds*. Financial Times, Prentice Hall. Pearson Education.

Bremdal, B. A., & Kirkemo, K. (2008) *The Knowledge-Craft project - EU R&D proposal.* ST-FH C1011, Statoil June 23, 2008

Bremdal, B. A., & Korsvold, T. (2009). *Why, what and how charts: Towards a method for analyzing and designing tools, arenas and organizations for improved collective intelligence*. Narvik University College Report, (revised version 2011).

Bremdal, B. A. (2001). The HBS method. In *Norwegian: HBS metodikken. Basert på FAROS Metodebok for HAMP Business System) v1.1 juni 2001*. Hydro Aluminium.

Brett, J. F. (2007). *Lessons from history: The value of competent people. Talent & Technology, 1(1)*. Society of Petroleum Engineers.

Bretton Woods Project. (2011). *Groupthink: IMF slammed for mistakes before crisis*. Bretton Wood Update, No 74, Jan-Feb. Retrieved from http://www.brettonwoodsproject.org/art-567577

Brooke, J. (1996). SUS: A "quick and dirty" usability scale. In P. Jordan, B. Thomas, & B. Weerdmeester (Eds.), *Usability evaluation in industry* (pp. 189-194). London, UK: Taylor and Francis. Retrieved December 26, 2011, from http://hell.meiert.org/core/pdf/sus.pdf

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning, and innovating. *Organization Science: A Journal of the Institute of Management Sciences, 2*(1), 40.

Brufau, A. (2008). The future of the oil market: The great investment challenge. In Brufau, A. (Ed.), *Oil, gas, energy: A plural view, a calm look*. Madrid, Spain: Estudios de Politica Exterior.

Brulé, M., Charalambous, Y., Crawford, M., & Crawley, C. (2008, September). *Bridging the gap between real-time optimization and information-based technologies*. Denver, CO: SPE Annual Technical Conference and Exhibition.

Brunsson, N. (1989). *The organization of hypocricy. Talk, decisions and actions in organizations*. Chichester, UK: John Wiley & Sons.

Bryman, A., & Bell, E. (2011). *Business research methods*. Oxford, UK: Oxford University Press.

Buchanan, B. G., & Shortliffe, E. H. (1984). *Rule-based expert systems: The MYCIN experiments of the Stanford heuristic programming project*. Reading, MA: Addison-Wesley Publishing Company.

Buchanan, D., & Huzcynski, A. (2010). *Organizational behaviour: An introductory text* (7th ed.). New York: Prentice Hall.

Burke, C. S., Priest, H. A., & Wooten, S. R. DiazGranados, D., & Salas, E. (2009). Understanding the cognitive processes in adaptive multicultural teams: A framework. In E. Salas, G. F. Goodwin, & C. S. Burke (Eds.), *Team effectiveness in complex organization. Cross-disciplinary perspectives and approaches*. New York, NY: Routledge.

Burnes, B. (2004). Kurt Lewin and the planned approach to change: A re-appraisal. *Journal of Management Studies*, *41*, 977–1002. doi:10.1111/j.1467-6486.2004.00463.x

Burns, B. (2009). *Managing change*. Harlow, UK: Financial Times/Prentice Hall.

Burns, T., & Stalker, G. M. (1961). *The management of innovation*. London, UK: Tavistock Publications.

Byrkjeflot, H. (Ed.). (1997). *Fra styring til ledelse (From management (control) to leadership)*. Bergen, Norway: Fagbokforlaget.

Callone, M. (1986). In Law, J. (Ed.), *Some elements of a sociology of translation: dOmestication of the scallops and the fisherman* (pp. 196–229).

Callon, M. (1991). Techno-economic networks and irreversability. In Law, J. (Ed.), *A sociology of monsters, essays on power, technology and domination* (pp. 132–165). London, UK: Routledge.

Camarinha-Matos, L. M., Afsarmanesh, H., Ferrada, F., Pereira-Klen, A., & Ermilova, E. (2006). *Rough reference model for collaborative networks*. D52.2, ECOLEAD project.

Campos, S. R. V., et al. (2006). *Right time decision of artificial lift management for fast loop control.* Paper presented at the Intelligent Energy Conference, SPE 99956-MS.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455. doi:10.1287/orsc.13.4.442.2953

Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science*, *15*(5), 555–568. doi:10.1287/orsc.1040.0094

Cassells, E. (1999). Building a learning organization in the offshore oil industry. *Long Range Planning*, *32*(2), 245–252. doi:10.1016/S0024-6301(99)00023-0

Castells, M. (1996). *The rise of the network society*. Oxford, UK: Blackwell.

CERA. (2006). *The digital oil field of the future: Making the transition from vision to implementation*. Cambridge, MA: Cambridge Energy Research Associates.

Chapman, A., & Forbes, P. (2010, March). *Smart oil and the development of the networked organisation.* SPE-128452, Presented at the SPE Intelligent Energy Conference and Exhibition held in Utrecht, The Netherlands.

Chief Counsel. (2011). *Macondo. The Gulf oil disaster*. Chief Counsels's Report.

Churchill, E. F., & Snowdon, D. (1998). Collaborative virtual environments: An introductory review of issues and systems. *Virtual Reality (Waltham Cross)*, *3*, 3–15. doi:10.1007/BF01409793

Clampitt, P. G. (2005). *Communicating for managerial effectiveness* (3rd ed.). London, UK: Sage Publications.

Clark, K. B., & Fujimoto, T. (1990). The power of product integrity. *Harvard Business Review*, (n.d), 11.

Conference and Exhibition, Utrecht, The Netherlands, March 23-25 2010.

Conger, J. (2000). Effective change begins at the top. In Beer, M., & Nohria, N. (Eds.), *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Cross, R. L., & Parker, A. (2004). *The hidden power of social networks: Understanding how work gets done in organizations*. Boston, MA: Harvard Business School Press.

Cummings, T., & Worley, C. (2009). *Organization development & change*. Mason, OH: South-Western.

Cusumano, M. A., & Gawer, A. (2002). The elements of platform leadership. *Sloan Management Review*, *43*(3), 51–58.

Dagestad, J. O., Saeverhagen, E., Nathan, E., Knutsen, S., & Norsk Hydro. (Amsterdam 2007). *Multi-skilling as a key factor for economically viable operations in a mature oil province: Oseberg East as a case example.*

Danilovic, M. (2006). Bring your suppliers into your projects - Managing the design of work packages in product development. *Journal of Purchasing and Supply Management*, *12*, 246–257. doi:10.1016/j.pursup.2006.10.009

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston, MA: Harvard Business School Press.

Davis, G. (1998). *Creating scenarios for your company's future*. Paper presented at The Conference on Corporate Environmental. Health and Safety Excellence, New York City – 28 April 1998

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *Management Information Systems Quarterly*, *13*(3), 319–340. doi:10.2307/249008

Day, D. V., Gronn, P., & Salas, E. (2004). Leadership capacity in teams. *The Leadership Quarterly*, *15*, 857–880. doi:10.1016/j.leaqua.2004.09.001

Day, D. V., Gronn, P., & Salas, E. (2006). Leadership in team-based organizations: On the threshold of a new era. *The Leadership Quarterly*, *17*, 211–216. doi:10.1016/j.leaqua.2006.02.001

de Best, L., & Van den Berg, F. (2006, October). *SPE-103575: Smart fields – Making the most of our assets.* Paper presented at the SPE Russian Oil and Gas Technical Conference and Exhibition, Moscow, Russia.

De la Vega, E., Sandoval, G., Garcia, M., Nunez, G., Al-Kinani, A., & Holy, R. W. … Mota, M. (2010, March). *Integrating data mining and expert knowledge for an artificial lift advisory system*. Utrecht, The Netherlands: SPE Intelligent Energy Conference and Exhibition.

de Sitter, L. U., den Hertog, J. F., & Dankbaar, B. (1997). From complex organizations with simple jobs to simple organizations with complex jobs. *Human Relations*, *50*(5), 497–534. doi:10.1177/001872679705000503

DeChurch, L., & Zaccharo, S. (2010). Perspective: Teams won't solve this problem. *Human Factors*, *52*, 329–334. doi:10.1177/0018720810374736

Derenzi, D., et al. (2009). *A successful approach in integrating people, process, and technology inside collaborative environments: A practical view of challenges and lessons learned*. Paper presented at the Intelligent Energy Conference, SPE 123287-MS.

Dijkstra, A. (2006). Safety management in airlines. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering concepts and precepts*. Hampshire, UK: Ashgate Publishing Ltd.

DiMaggio, P. J., & Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, *48*, 147–160. doi:10.2307/2095101

Dosi, G., & Marengo, L. (1994). Toward a theory of organizational competences. In England, R. W. (Ed.), *Evolutionary concepts in contemporary economics*. Michigan University Press.

Downie, R. D. (2005). Defining integrated operations. *Joint Force Quarterly*, *28*, 10–13.

Driskell, J. E., Radtke, P. H., & Salas, E. (2003). Virtual teams: Effects of technology mediation on team performance. *Group Dynamics*, *7*, 297–323. doi:10.1037/1089-2699.7.4.297

Drøivoldsmo, A., Kvamme, J. L., Nystad, E., Lunde-Hanssen, L. S., Larsen, R., & Berge-Leversen, T. (2007). *Integrated operations and insights on functional analysis techniques.* Paper presented at the Joint 8th IEEE Conference on Human Factors and Power Plants and 13th Annual Workshop on Human Performance, Monterey, CA.

Duncan, R. (1979). What is the right organization structure? Decision tree analysis provides the answer. *Organizational Dynamics*, *7*(3), 59–80. doi:10.1016/0090-2616(79)90027-5

Duncan, R. B. (1976). The ambidextrous organization. Designing dual structures for innovation. In Kilmann, R. H., Pondy, L. R., & Slevin, D. P. (Eds.), *The management of organization: Strategy and implementation*. New York, NY: North Holland.

Dunphy, D. (2000). Top-down versus participative management of organizational change. In Beer, M., & Nohria, N. (Eds.), *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Dutra, T., et al. (2010). *Monitoring and optimizing oil fields by a real-time production operation (RTPO) system*. Presented at the Intelligent Energy Conference, SPE 138316-MS.

Dweck, C. (2008). *Mindset: The new psychology of success*.

Edquist, C. (2005). Systems of innovation: Perspectives and challenges. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

Edwards, T., Mydland, Ø., & Henriquez A. (2010). *The art of intelligent energy (iE)- Insights and lessons learnt from the application of iE.* SPE-paper 128669, Presented at Intelligent Energy conference in Utrecht, February.

Edwards, T., Saunders, M., & Moore-Cernoch, K. (2006). *Advanced collaborative environments in BP.* SPE-paper 100113. Presented at SPE-conference Intelligent Energy Amsterdam, April

Eike, M. (2009). *Capacity for innovation – The implementation of integrated operations within a Norwegian drilling contractor*. University of Bergen.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. doi:10.5465/AMJ.2007.24160888

Elkjær, B. (2004). Organizational learning: 'The third way'. *Management Learning*, *35*(4), 419–434. doi:10.1177/1350507604048271

Emery, M., & Purser, R. E. (1996). *The search conference – A method for planning organizational change and community action*. San Francisco, CA: Jossey-Bass Publishers.

Encyclopedia.com. (2011). Peer influence. In *International encyclopedia of marriage and family*.

Endsley, M. R. (1988). Design and evaluation for situation awareness enhancement. *Proceedings of the Human Factors Society 32th Annual Meeting* (pp. 97-101). Santa Monica, CA: Human Factors Society.

Endsley, M. R., Bolté, B., & Jones, D. G. (2003). *Designing for situation awareness. An approach to user- centered design*. London, UK: Taylor Francis.

Eppler, M. J., & Aeschimann, M. (2008). *Envisioning risk: A systematic framework for risk visualization in risk management and communication.* ICA Working Paper 5/2008. Retrieved December 26, 2011, from http://www.knowledge-communication.org/pdf/envisioning-risk.pdf

Farnham: Ashagate Øien, K., Massaiu, S., Tinmannsvik, R. K., & Størseth, F (2010a). *Development of early warning indicators based on Resilience Engineering.* Paper presented at PSAM10 (International Probabilistic Safety Assessment and Management Conference), 7–11 June 2010, Seattle, USA. Ø–11,

Fedor, D. B., Caldwell, S., & Herold, D. M. (2006). The effects of organizational changes on employee commitment: A multilevel investigation. *Personnel Psychology*, *59*(1). doi:10.1111/j.1744-6570.2006.00852.x

Feineman, D. R. (2009, April). *SPE-122676: Realizing value from real time monitoring in Greenfield Assets.* Paper presented at the SPE Digital Energy Conference & Exhibition, Houston, Texas, U.S.A.

Filicetti, J. (2007). *Project management dictionary*. Retrieved from http://www.pmhut.com/pmo-and-project-management-dictionary

Finest. (2011). *Future internet enabled optimization of transport and logistics business networks*. Retrieved from http://www.finest-ppp.eu/

Flin, R. H. (1997). Crew resource management for teams in the offshore oil industry. *Team Performance Management*, *3*(2), 121–129. doi:10.1108/13527599710190876

Ford, D. N., & Sterman, J. D. (2003). The liars club: Concealing rework in concurrent development. *Concurrent Engineering: Research and Applications*, *11*(3), 211–219. doi:10.1177/106329303038028

Ford, J. D., Ford, L. W., & D'Amelio, A. (2008). Resistance to change: The rest of the story. *Academy of Management Review*, *33*(2), 362–377. doi:10.5465/AMR.2008.31193235

Formigli-Filho, J. M., et al. (2009). *Santos Basin's pre-salt reservoirs development: The way ahead*. Paper presented at the Offshore Technology Conference, OTC 19953-MS.

Galbraith, J. R. (2009). *Designing matrix organizations that actually work: How IBM, Procter & Gamble, and others design for success*. San Francisco, CA: Jossey-Bass.

Gambetta, D. (1988). *Trust: Making and breaking cooperative relations*. New York, NY: Basil Blackwell.

Gauthereau, V., & Hollnagel, E. (2005). Planning, control, and adaptation: A case study. *European Management Journal*, *23*(1), 118–131. doi:10.1016/j.emj.2004.12.016

Gazi, N. H., Hottman, W. E., Logan, J. L., & Verrett, R. C. (1995, March). *SPE-29793: Alliances and partnering: A new relationship between oil/gas producing companies and service companies*. Paper presented at the SPE Middle East Oil Show, Bahrain, U.A.E.

Gerrard, C. A., McCabe, H., & Beck, A. D. (2010, March). *SPE-127849: Installation and implementation of "Smart Fields Foundation" on a brown field asset, adding value without major capital investment*. Paper presented at the SPE Intelligent Energy Conference held in Utrecht, The Netherlands.

Gerstner, L. (2002). *Who says elephants can't dance? Inside IBM's historic turnaround.* Harper Collins Publisher. Henderson, J. C., & Kulatilaka, N. (2008). *Principles of capabilities platforms*. Boston University Working paper.

Gherardi, S. (2006). *Organizational knowledge: The texture of workplace learning*. Malden, MA: Blackwell.

Gherardi, S., & Nicolini, D. (2000). The organizational learning of safety in communities of practice. *Journal of Management Inquiry*, *9*(1), 7–18. doi:10.1177/105649260091002

Giddens, A. (1984). *The constitution of society*. Cambridge, MA: Polity Press.

Giddens, A. (1991). *Modernity and self-identity*. Stanford, CA: Stanford University Press.

Giddens, A. (1994). Risk, trust, reflexitivity. In Beck, U., Giddens, A., & Lash, S. (Eds.), *Reflexive modernization*. Cambridge, UK: Polity Press.

Gobeli, D. H., & Larson, E. W. (1986). Matrix management: More than a fad. *Engineering Management International*, *4*, 71–76. doi:10.1016/0167-5419(86)90009-8

Godar, S. H., & Ferris, S. P. (2004). *Virtual and collaborative teams*. Hershey, PA: Idea Group Publishing.

Goold, M., & Campbell, A. (2003). Making matrix structures work: creating clarity on unit roles and responsibility. *European Management Journal*, *21*(3), 351–363. doi:10.1016/S0263-2373(03)00048-3

Gottschalk, P. (2005). *Strategic knowledge management technology*. Hershey, PA: Idea Group.

Grant, R. M., & Cibin, R. (1996). Strategy, structure and market turbulence: The international oil majors, 1970 – 1991. *Scandinavian Journal of Management*, *12*(2), 165–188. doi:10.1016/0956-5221(95)00031-3

Green, M. (2007). *Change management masterclass: A step by step guide to successful change management*. London, UK: Kogan Page.

Grøtan, T. O., & Størseth, F. (2011). Integrated safety management based on organizational resilience. In *Proceedings of ESREL 2011.*

Grötan, T. O., Albrechtsen, E., Rosness, R., & Bjerkebaek, E. (2010). The influence on organizational accident risk by integrated operations in the petroleum industry. *Safety Science Monitor, 1*(14).

Groth, L. (1999). *Future organizational design: The scope for the IT-based enterprise*. Chichester, UK: John Wiley & Sons.

Gulbrandsøy, K., Andersen, T. M., Hepsø, V., & Sjong, D. (2004). *Integrated operations and e-fields in maintenance and operation: the third efficiency leap facing the Norwegian oil and gas industry*. Paper presented at the MARCONI Conference.

Guldemond, E. (2011). *Collaborative work environments in smart oil fields.* Doctoral dissertation. Nijmegen, The Netherlands: Radbout University Nijmegen.

Guldemond, E., & ten Have, K. (2008, February). *SPE-112173 group mental models in collaborative work environments.* Paper presented at the SPE Intelligent Energy Conference and Exhibition held in Amsterdam, The Netherlands.

Guldemond, E., ten Have, K., & Knoppe, R. (2010). *Organizational structures in collaborative work environments: The return of the matrix?* SPE paper 128274. Paper presented at Intelligent Energy Conference, Utrecht, Netherlands, 25-27 February 2010. Society of Petroleum Engineers.

Guldenmund, F. W. (2000). The nature of safety culture: A review of theory and research. *Safety Science*, *34*, 215–257. doi:10.1016/S0925-7535(00)00014-X

Haavik, T. (2010). Chasing shared understanding in drilling operations. *Cognition Technology and Work*, *13*(4). Retrieved from http://www.springerlink.com/content/n0l6823328713x35/

Haavik, T. (2010a). Making drilling operations visible: The role of articulation work for organisational safety. *Cognition Technology and Work*, *12*(4), 285–295. doi:10.1007/s10111-010-0139-2

Haavik, T. (2011). Challenging controversies: A prospective analysis of the influence of new technologies on the safety of offshore drilling operations. *Journal of Contingencies and Crisis Management*, *19*(3).

Hackman, J. R. (1994). Tripwires in designing and leading workgroups. *Occupational Psychology*, *23*, 3–8.

Hackman, J. R. (Ed.). (1990). *Groups that work (and those that don't): Conditions for effective teamwork*. San Francisco, CA: Jossey Bass.

Hagist, P. W. (1994). *SPE-28358: The conversion to team based organizations*. Paper presented at the 69th Annual Technical Conference and Exhibition held in New Orleans, LA, U.S.A.

Hamel, G., & Prahalad, C. K. (1994). *Competing for the future*. Boston, MA: Harvard Business School Press.

Hammer, M., & Champy, J. (2001). *Reengineering the corporation: A manifesto for business revolution*. New York, NY: HarperCollins.

Hansen, C. D., & Johnson, C. R. (Eds.). (2005). *The visualization handbook*. Amsterdam, The Netherlands: Elsevier-Butterworth Heinemann.

Hansen, M. T. (2009). *Collaboration. How leaders avoid the traps, create unity, and reap big results*. Boston, MA: Harvard Business Press.

Hatch, D. (2009). *Operational business intelligence: Five things you need to know about improving your costumer-facing performance*. Aberdeen Group. Retrieved August 10, 2011, from https://www1.vtrenz.net/imarkownerfiles/ownerassets/1076/5392-RA-Operational_BI-DH-04-NSP1.PDF

Hauser, M., & Gilman, H. (2010, February). *SPE 112215: Evolution of decision environments: Lessons learned from global implementations and future direction of decision environments.* Paper presented at SPE Intelligent Energy Conference, Amsterdam, Netherlands.

Hayes, N. (2002). *Managing teams: A strategy for success*. Stamford, CT: Thomson Learning.

Heaney, M., & Davidson, J. (2006, April). *SPE-99885: Beyond the big crew change, dumbing down or getting smarter?* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Heath, C., & Luff, P. (1996). Convergent activities: Line control and passenger information on the London Underground. In Engström, Y., & Middleton, D. (Eds.), *Cognition and communication at work*. New York, NY: Cambridge University Press.

Hecksher, C., Donnellon, A., & Appelgate, L. M. (Eds.). (1994). *The post-bureaucratic organization: New perspectives on organizational change*. Los Angeles, CA: Sage.

Heinrich, H. W. (1931). *Industrial accident prevention*. New York, NY: McGraw-Hill.

Henderson, G. (2005, May). *OTC-17727: The impact of digital technologies on the global Shell EP business.* Paper presented at the 2005 Offshore Technology Conference, Houston, Texas, U.S.A.

Henderson, J. C. (2011). Coordinating distributed real-time business processes: Understanding the synchronization problem. Presented at International Conference on Information Systems (ICIS) 2011, December 4-7 Shanghai.

Henderson, J., Hepsø, V., & Mydland, Ø. (2012). What is a capability platform approach to integrated operations? -An introduction to key concepts. In Rosendahl, T., & Hepsø, V. (Eds.), *Integrated operations in the oil and gas industry: Sustainability and capability development*. Hershey, PA: IGI Global.

Henriquez, A., Fjærtoft, I., Yttredal, O., & Johnsen, C. (2008). *Enablers for the successful implementation of intelligent energy: The Statoil case*. Intelligent Energy Conference and Exhibition, 25-27 February 2008, Amsterdam, The Netherlands.

Henriquez, A., Fjaertoft, I., Johnsen, C., Yttredal, O., & Gabrielsen, T. (2007). Integrated operations: How Statoil is managing the challenge of change. *Management Focus*, (n.d), 25.

Hepsø, V. (2006). *When are we going to address organizational robustness and collaboration as something else than a residual factor?* Society Petroleums Engineers Paper 1000712. Presented at the Society of Petroleum Engineers (SPE) conference Intelligent Energy, Amsterdam, The Netherlands, April, 2006.

Hepsø, V., & Gramvik, G. (2011). *What is a capability and a capability platform approach to integrated operations? An introduction to key concepts*. Working paper.

Hepsø, V., Olsen, H., Joannette, F., & Brych, F. (2010). *Next-steps to a framework for global collaboration to drive business performance.* SPE-paper 126207. Presented at Intelligent Energy Conference in Utrecht, February.

Hepsø, V. (2008). Boundary-spanning practices and paradoxes related to trust among people and machines in a high-tech oil and gas environment. In Jemielniak, D., & Kociatkiewicz, J. (Eds.), *Management practices in high-tech environments* (pp. 1–17). Hershey, PA: Idea Group. doi:10.4018/978-1-59904-564-1.ch001

Hepsø, V. (2009). The role of 'common' information spaces in knowledge intensive work. Representation and negotiation of meaning among oil and gas subsurface specialists in computer supported collaboration rooms. In Jemielniak, D., Kozminski, L., & Kociatkiewicz, J. (Eds.), *Handbook of research on knowledge-intensive organizations* (pp. 279–294). Hershey, PA: Idea Group. doi:10.4018/978-1-60566-176-6.ch017

Hepsø, V., Munkvold, G., Rolland, K., & Olsen, H. H. (2009). Ny praksis produksjonsoptimalisering muliggjort av integrert operasjon. Spredningen av detaljert produksjonsoptimalisering (DPO). In Hepsø, I. L., & Kongsvik, T. (Eds.), *Forskning som endringsverktøy i organisasjoner*. Trondheim, Norway: Tapir.

Herbert, M., Pedersen, J., & Pedersen, T. (2003). *A step change in collaborative decision making – onshore drilling center as the new work space.* SPE Annual Technical Conference and Exhibition, 5-8 Oct. 2003, Colorado, US.

Herscovitch, L., & Meyer, J. P. (2002). Commitment to organizational change: Extension of a three-component model. *The Journal of Applied Psychology*, *87*, 474–487. doi:10.1037/0021-9010.87.3.474

Hertel, G., Konradt, U., & Orlikowski, B. (2004). Managing distance by interdependence: Goal setting, task interdependence, and team-based rewards in virtual teams. *European Journal of Work and Organizational Psychology*, *13*(1), 1–28. doi:10.1080/13594320344000228

Hertel, G., Konradt, U., & Voss, K. (2006). Competencies for virtual teamwork: Development and validation of a web- based selection tool for members of distributed teams. *European Journal of Work and Organizational Psychology*, *15*(4), 477–504. doi:10.1080/13594320600908187

Hiatt, J., & Creasey, T. (2010). *The definition and history of change management.* Retrieved from http://www.change-management.com/tutorial-definition-history.htm

Hickman, A., Guidry, A., & Seaton, S. (2008, February). *112141-MS: Real-time collaboration – efficient problem solving and extending resources*. Paper Presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Hite, J. R., Crawley, C., Deaton, D. F., Farid, K., & Sternevsky, M. (2007, November). *Barriers to implementation of real-time optimization technology.* Anaheim, CA: SPE Annual Technical Conference and Exhibition.

Holland, J. H. (1975). *Adaptation in natural and artificial systems*. Ann Arbor, MI: University of Michigan Press.

Holland, J. H. (1995). *Hidden order - How adaptation builds complexity*. Reading, MA: Addison Wesley.

Hollnagel, E., Tveiten, C. K., & Albrechtsen, E. (2010). *Resilience engineering and integrated operations in the petroleum industry*. IO center white paper.

Hollnagel, E. (2011). Epilogue: RAG – The resilience analysis grid. In Hollnagel, E., Pariés, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice*. Farnham, UK: Ashgate.

Hollnagel, E. (Forthcoming). A resilience engineering approach to assess major accidents risk in IO. To be published. In Albrechtsen, E., & Besnard, D. (Eds.), *Interdisciplinary risk assessment in integrated operations*.

Hollnagel, E., & Woods, D. D. (2006). Epilogue: Resilience engineering precepts. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering concepts and precepts*. Hampshire, UK: Ashgate Publishing Ltd.

Hollnagel, E., Woods, D. D., & Leveson, N. (2006). *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Holst, B., & Nystad, E. (2007). *Oil and gas offshore/ onshore integrated operations – Introducing the Brage 2010+ project.* Paper presented at the Joint 8th IEEE HFPP / 13th HPRCT.

Holt, D. T., Armenakis, A. A., Field, H. S., & Harris, S. G. (2007). Readiness for organizational change: The systematic development of a scale. *The Journal of Applied Behavioral Science*, *43*(2), 232–255. doi:10.1177/0021886306295295

Hopkins, A. (2009). *Failure to learn: The BP Texas City refinery disaster.* Sydney, Australi: CCH Australia.

Hopkins, A. (2000). *Lessons from Longford: The Esso gas plant explosion*. Sydney, Australia: CCH Australia Ltd.

Hovden, J. (2004). *Sikkerhet i forskning og praksis: Et utfordrende mangfold med Sikkerhetsdagene som arena. Fra flis i fingeren til ragnarok* (p. 44). Trondheim, Norway: Tapir Akademiske Forlag.

Howe, J. (2008). *Crowdsourcing: Why the power of the crowd is driving the future of business*. New York, NY: Crown Business.

Hyne, N. J. (2001). *Nontechnical guide to petroleum geology, exploration, drilling, and production*. Tulsa, OK: PennWell Corporation.

Intelligent Conference and Exhibition, Utrecht, The Netherlands, March 23-25 2010.

Iyer, B., & Henderson, J. C. (2010). Preparing for the future: Understanding the seven capabilities of cloud computing. *MIS Quarterly Executive*, *9*(2), 117–131.

Janis, I. L. (1972). *Victims of groupthink: A psychological study of foreign-policy decisions and fiascoes*. Atlanta, GA: Houghton Mifflin.

Janis, I. L., & Mann, L. (1977). *Decision making: A psychological analysis of conflict, choice, and commitment*. New York, NY: The Free Press.

Jarvenpaa, S. L., Knoll, K., & Leidner, D. E. (1998). Anybody out there? Antecedents of trust in global virtual teams. *Journal of Management Information Systems*, *14*(4), 29–64.

Jensen, F. V., & Nielsen, T. D. (2001). *Probabilistic decision graphs for optimization under uncertainty*. New York, NY: Springer-Verlag.

Johannesen, J.-A., & Rosendahl, T. (2010). *Prosjektkommunikasjon* [Project communication]. Cappelen Akademisk Forlag.

Johnsen, S. O., Lundteigen, M. A., Fartum, H., & Monsen, J. (2005). *Identification and reduction of risks in remote operations of offshore oil and gas installations. ESREL 2005*. Poland: Tri-City.

Johnson, P. J. (2010). Python for collective intelligence and collaborative filtering. *The Python Papers Monograph 2:8, Proceedings of PyCon Asia-Pacific 2010*.

Johnson, P. M. (2001). *Effects of groupthink on tactical decision-making*. School of Advanced Military Studies, United States Army Command and General Staff College, Fort Leavenworth, Kansas, First Term AY 00-01. Monograph.

Johnson, P. E. (1983). What kind of expert should a system be? *The Journal of Medicine and Philosophy*, *8*(1), 77–97.

Judson, J., & Ella, R. (2007, November). *Documenting DOFF value.* Paper presented CERA Executive Workshop, The Digital Oil Field of the Future (DOFF) Forum in Houston, USA.

Julsrud, T. E. (2008). *Trust across distance. A network approach to the development, distribution, and maintenance of trust in distributed work groups*. Doctoral thesis, Norwegian University of Science and Technology.

K., Tinmannsvik, R. K., Massaiu, S., & Størseth, F. (2010b). *Development of new models and methods for the identification of early warning indicators*. SINTEF report no A16930.

Kaarstad, M., Rindahl, G., Torgersen, G., & Drøivoldsmo, A. (2009). *Interaction and interaction skills in an integrated operations setting*. Paper presented at The IEA (International Ergonomics Association) 17th World Congress on Ergonomics, Beijing, August 2009.

Kaminski, D. (2004). *Remote real time operations centre for geologically optimised productivity.* Chapter presented at the AAPG International Conference, Cancun, Mexico.

Kasper-Fuehrer, E. C., & Ashkanasy, N. M. (2001). Communicating trustworthiness and building trust in interorganizational virtual organizations. *Journal of Management*, *27*, 235–254.

Katzenbach, J. R., & Smith, D. K. (1993). *The wisdom of teams*. Boston, MA: Harvard Business School.

Kerman, M. C., Jiang, W., Blumberg, A. F., & Buttrey, S. E. (2009). Event detection challenges, methods, and applications in natural and artificial systems. *14th International Command and Control Research and Technology Symposium (ICCRTS)* (p. 58). Washington, DC: Lockheed Martin.

Khan, F. I., & Haddara, M. M. (2003). Risk-based maintenance (RBM): a quantitative approach for maintenance/inspection scheduling and planning. *Journal of Loss Prevention in the Process Industries*, *16*, 561–573. doi:10.1016/j.jlp.2003.08.011

Kirkman, B. L., Rosen, B., Tesluk, P. E., & Gibson, C. B. (2004). The impact of team empowerment on virtual performance: The moderating role of face-to-face interaction. *Academy of Management Journal*, *47*(2), 175–192. doi:10.2307/20159571

Klein, S. J., & Rosenberg, N. (1986). An overview of innovation. In Landau, R., & Rosenberg, N. (Eds.), *The positive sum strategy. Harnessing technology for economic growth*. Washington, DC: National Academy Press.

Knight, K. (1976). Matrix organization: A review. *Journal of Management Studies*, *13*(2), 111–130. doi:10.1111/j.1467-6486.1976.tb00528.x

Knoppe, R., & Holloway, S. (2008, February). *SPE-112060: The application of knowledge and continuous learning to the implementation of collaborative work environments at Shell.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Knowles, E. S., & Linn, J. A. (2004). The importance of resistance to persuasion. In Knowles, E. S., & Linn, J. A. (Eds.), *Resistance and persuasion* (pp. 3–9). Mahwah, NJ: Lawrence Erlbaum Associates.

Kogut, B., & Kulatilaka, N. (2001). Capabilities as real options. *Journal Organizational Science*, *12*(6).

Kolodny, H. F. (1979). Evolution to a matrix organization. *Academy of Management Review*, *4*(4), 543–553.

Korsvold, T., Haavik, T., Johnsen, S. O., Danielsen, J. E., Herbert, M., Rommetveit, R., & Bremdal, B. A. (2009). *Creating resilient drilling operations through collective learning.* Paper SPE 124039 presented at SPE Asia Pacific Health, Safety, Security, and Environment Conference and Exhibition held in Jakarta, Indonesia, 4–6 August 2009. Retrieved from http://www.onepetro.org/mslib/app/Preview.do?paperNumber=SPE-124039-MS&societyCode=SPE

Korsvold, T., Hansson, L., & Lauvsnes, A. (2009). *Approaching and creating new work practices through action research – A case study from implementation of integrated operations (IO) in a Norwegian oil and gas company.* EGOS conference, Barcelona Spain 2009.

Kotlarsky, J., & Oshri, I. (2005). Social ties, knowledge sharing and successful collaboration in globally distributed system development projects. *European Journal of Information Systems*, *14*, 37–48. doi:10.1057/palgrave.ejis.3000520

Kotter, J. P. (1995). *The new rules: How to succeed in today's post-corporate world*. New York, NY: Free Press.

Kotter, J. P. (1996). *Leading change*. Boston, MA: Harvard Business School Press.

Kotter, J. P., & Cohen, D. S. (2002). *The hearth of change*. Boston, MA: Harvard University Press.

Kotterman, J. (2006). Leadership versus management – What is the difference? *Journal for Quality and Participation*, *29*(2), 13–17.

Koufteros, X., Vonderembse, M., & Doll, W. (2001). Concurrent engineering and its consequences. *Journal of Operations Management*, *19*, 97–115. doi:10.1016/S0272-6963(00)00048-6

Kramer, R. M., & Tyler, T. R. (1996). *Trust in organizations: Frontiers of theory and research*. Thousand Oaks, CA: Sage.

Krause, T. R., Hidley, J. H., & Hodson, S. J. (1990). *The behavior-based safety process: Managing involvement for an injury-free culture*. New York, NY: Van Nostrand Reinhold.

Kray, L. J., & Galinsky, A. D. (2003). The debiasing effect of counterfactual mind-sets: Increasing the search for disconfirmatory information in group decisions. *Organizational Behavior and Human Decision Processes*, *91*, 69–81. doi:10.1016/S0749-5978(02)00534-4

Kvale, S. (1996). *Inter views: An introduction to qualitative research interviewing*. Thousand Oaks, CA: Sage Publications.

Ladegård, G., & Vabo, S. I. (Eds.). (2010). *Ledelse og styring*. Oslo, Norway: Fagbokforlaget.

Lameda, R., & Van den Berg, F. (2009). *Integration is about people, SPE-123352.* Presented at the SPE Digital Energy Conference & Exhibition, Houston USA.

Lameda, R., & Van den Berg, F. (2009, April). *SPE-123352: Integration is about people.* Paper presented at the SPE Digital Energy Conference & Exhibition, held in Houston, U.S.A. Lawrence, P. R., Kolodny, H. F., & Davis, S. M. (1977). The human side of the matrix. *Organizational Dynamics*, *6*(1), 43–61.

Lamvik, G., Næsje, P. C., Skarholt, K., & Torvatn, H. (2009). Paperwork, management and safety: Towards a bureaucratization of working life and a lack of hands-on supervision. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory methods and applications*. London, UK: Taylor & Francis Group.

Langley, A., & Denis, J. L. (2006). Neglected dimensions of organizational change: Towards a situated view. In Lines, R., Stensaker, I. G., & Langley, A. (Eds.), *New perspectives on organizational change and learning*. Bergen, Norway: Fagbokforlaget.

LaPorte, T. R., & Consolini, P. (1991). Working in theory but not in practice: Theoretical challenges in high reliability organizations. *Journal of Public Administration: Research and Theory*, *1*, 19–47.

Latour, B. (1986). *Science in action*. Cambridge, MA: Harvard University Press.

Lauche, K., & Krämer, R. (2005). *Innovations in onshore drilling centres*. XII EAWOP Conference, Istanbul, May 12-15.

Lauche, K., Sawaryn, S. J., & Thorogood, J. L. (2006). *Capability development with remote drilling operations.* Chapter presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Lauvsnes, A., & Korsvold, T. (2010). *Development and validation of technology acceptance model for integrated operations (IO) – TAM-IO*. SINTEF Report F17610.

Lave, J. Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Law, J. (2004). *After method: Mess in social science research*. London, UK: Routledge.

Lawler, E., & Worley, C. (2009). Designing organizations that are built to change. In Hesselbein, F., & Goldsmith, M. (Eds.), *The organization of the future*. San Fransisco, CA: Jossey-Bass.

Lawson, E., & Price, C. (2003). The psychology of change management. *McKinsey Quarterly, June*. Retrieved from https://www.mckinseyquarterly.com

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, *40*, 191–204. doi:10.1016/S0378-7206(01)00143-4

Letnes, B., & Korsvold, T. (2008). *Managing change with the integrated drilling simulator*. F6518/ 36.6417.00/03/08 SINTEF Report

Leveson, N. A. (2004). New accident model for engineering safer systems. *Safety Science*, *42*, 237–270. doi:10.1016/S0925-7535(03)00047-X

Levina, N., & Vaast, E. (2005). The emergence of boundary-spanning competence in practice: Implications for implementation and use of information systems. *Management Information Systems Quarterly*, *29*(2), 335–363.

Levin, M., & Rolfsen, M. (2004). *Arbeid i team: Læring og utvikling i team* [Work in team. Learning and development in team]. Oslo, Norway: Fagbokforlaget.

Levitt, B. A. (1988). Organizational learning. *Annual Review of Sociology*, *14*, 319–338. doi:10.1146/annurev.so.14.080188.001535

Lewicki, R., & Bunker, B. B. (1995). Developing and maintaining trust in work relationships. In Kramer, R. M., & Tyler, T. R. (Eds.), *Trust in organizations: Frontiers of theory and research*. Thousand Oaks, CA: Sage. doi:10.4135/9781452243610.n7

Lewin (1951). *Field theory in social science: Selected theoretical papers*. New York, NY: Harper and Bros.

Lien, S., & Fremstad, J. K. (1989). Organisering av Organisasjonsendring. In Egeberg, M. (Ed.), *Institusjonspolitikk og Forvaltningsutvikling*. Oslo, Norway: Tano.

Lilleng, T., & Sagatun, S. I. (2010). *Integrated operations methodology and value proposition.* Paper presented at the SPE Intelligent Energy, Utrecht, NL.

Lima, C. B. C., et al. (2008). *GeDIg Carapeba - A journey from integrated intelligent field operation to asset value chain optimization*. Paper presented at the Intelligent Energy Conference, SPE 112191-MS.

Lima, C. B. C., et al. (2010). *State-of-art digital oilfield implementation in Petrobras Campos Basin*. Paper presented at the Intelligent Energy Conference, SPE 128766-MS.

Lines, R., Stensaker, I. G., & Langley, A. (2006). *New perspectives on organizational change and learning*. Oslo, Norway: Fagbokforlaget.

Lipnack, J., & Stamps, J. (1997). *Virtual teams – Reaching across space, time, and organizations with technology*. New York, NY: John Wiley & Sons, Inc.

Lurey, J. S., & Raisingham, M. S. (2001). An empirical study of best practices in virtual teams. *Information & Management*, *38*, 523–544. doi:10.1016/S0378-7206(01)00074-X

Madsen, B. E., & Hansson, L. (2011). *Closing the gap*. (SINTEF F216540).

Malhotra, A., Majchrzak, A., & Benson, R. (2007). Leading virtual teams. *The Academy of Management Perspectives*, *21*(1), 60–70. doi:10.5465/AMP.2007.24286164

Malone, T. W., & Crowston, K. (1994). The interdisciplinary study of coordination. *ACM Computing Surveys*, *26*(1), 87–119. doi:10.1145/174666.174668

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71–87. doi:10.1287/orsc.2.1.71

March, J., & Olsen, J. P. (1989). *Rediscovering institutions. The organizational basis of politics*. New York, NY: Free Press.

Maznevski, M. L., & Chudoba, K. M. (2000). Bridging space over time: Global virtual team dynamics and effectiveness. *Organization Science*, *11*(5), 473–492. doi:10.1287/orsc.11.5.473.15200

McEvily, B., Perrone, V., & Zaheer, A. (2003). Trust as an organizing principle. *Organization Science*, *14*(1), 99–103. doi:10.1287/orsc.14.1.91.12814

Meyer, J. P., & Allen, N. J. (1991). A three-component conceptualization of organizational commitment: Some methodological considerations. *Human Resource Management Review*, *1*, 61–89. doi:10.1016/1053-4822(91)90011-Z

Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In Kramer, R. M., & Tyler, T. R. (Eds.), *Trust in organizations: Frontiers of theory and research* (pp. 166–195). Thousand Oaks, CA: Sage. doi:10.4135/9781452243610.n9

Miligan, G., Deutekom, M., & Buchan, C. (2008, February). *Guided workflow for the digital oil field: A practical example*. Amsterdam, The Netherlands: SPE Intelligent Energy Conference and Exhibition.

Miller, K. I., & Monge, P. R. (1986). Participation, satisfaction, and productivity: A meta-analytic review. *Academy of Management Journal*, *29*(4), 727–753. doi:10.2307/255942

Mintzberg, H. (1983). *Structures in fives: Designing effective organizations*. Englewood Cliffs, NJ: Prentice Hall.

Miskimins, J. L. (2009). *Design and life-control loop considerations for unconventional-reservoir wells* (pp. 353–359). SPE Production & Operations.

Mitchell, T. (1997). *Machine learning*. Singapore: McGraw-Hill.

Moises, G. V., et al. (2008). *GeDIg: Petrobras corporate program for digital integrated field management*. Paper presented at the Intelligent Energy Conference, SPE 112153-MS.

Moldjord, C., Steiro, T. J., Firing, K., & Fredriksen, P. (2010). *Tough men cry. Learning from sharp end military aviation. ESREL 2010. September 5th-9th*. Greece: Rhodes.

Moltu, B. (2003). *BPR in Norwegian! The management concept of business process reengineering (BP) as a culturally praxis.* (Nr 2004:81) PhD Thesis, NTNU, Trondheim, Norway

Moltu, B., & Sæther, G. (2006). *Betre samhandling mellom hav og land – Evaluering av OPS rom i HNO*. Trondheim. STF50 F06057.Sintef

Moltu, B., & Sæther, G. G. (2004). *Betre samhandling mellom hav og land Evaluering av OPS-rom i HNO*. SINTEF Teknologi og samfunn rapport.

Moltu, B., Ringstad, A. J., & Guttormsen, G. (2008). *Consequence analysis as organisational development.* ESREL 2008.

Moltu, B., & Nærheim, J. (2010). IO design gives high efficiency. *SPE Economics & Management*, *2*(1), 32–37. doi:10.2118/126534-PA

Montara Commission of Inquiry. (2010). *Report of the Montara Commission of Inquiry.*

Monteiro, E., & Hanseth, O. (1996). Social shaping of intormation infrastructure: On being specific about the technology. In Orlikowski, W. J., Walsham, G., Jones, M., & DeGross, J. I. (Eds.), *Information technology and changes in organizational work* (pp. 325–343). London, UK: Chapman & Hall.

Morgan, G. (1986). *Images of organization*. Sage.

Morgeson, F. P., DeRue, D. S., & Karam, E. P. (2010). Leadership in teams: A functional approach to understanding leadership structures and processes. *Journal of Management*, *36*, 5–39. doi:10.1177/0149206309347376

Morris, R. L., & Lafitte, F. (1991, April). *SPE-22036: Consolidating and managing a mature portfolio.* Paper presented at the SPE Hydrocarbon Economics and Evaluation Symposium, Dallas, Texas.

Morton, S. C., Dainty, A. R. J., Burns, N. D., Brookes, N. J., & Backhouse, C. J. (2006). Managing relationships to improve performance: A case study in the global aerospace industry. *International Journal of Production Research*, *44*(16). doi:10.1080/00207540600577809

Murray, R., Edwards, C., Gibbons, K., Jakeman, S., & Jonge, G. de, Kimminau, S., … Vachon, G. (2006, April). *SPE-100024: Making our mature fields smarter – An industry-wide position.* Paper presented at the SPE Intelligent Energy and Exhibition, Amsterdam, The Netherlands

Nadler, D. A., & Tushman, M. L. (1997). *Competing by design: The power of organizational architecture*. New York, NY: Oxford University Press.

Næsje, P., Skarholt, K., Hepsø, V., & Bye, A. (2009). Empowering operation and maintenance: Safe operations with the "one directed team" organization model. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory methods and applications* (*Vol. 2*, pp. 1407–1421). London, UK: Taylor & Francis Group.

Nardi, B. A., & O'Day, V. L. (1999). *Information ecologies: Using technology with heart* (pp. 50–55). Cambridge, MA: MIT Press.

NASA. (2008). *Columbia crew survival report.* NASA/SP-2008-565 Report.

Nemeth, C. J. (1986). Differential contributions of majority and minority influence. *Psychological Review*, *93*, 23–32. doi:10.1037/0033-295X.93.1.23

Nemiro, J., Beyerlein, M., Bradley, L., & Beyerlein, M. (Eds.). (2008). *The handbook of high-performance virtual teams. A toolkit for collaborating across boundaries*. San Francisco, CA: Jossey-Bass.

Newell, A. (1982). The knowledge level. *Artificial Intelligence Magazine*, *18*(1), 87–127.

Newell, A., & Simon, H. (1972). *Human problem solving*. New Jersey: Prentice Hall.

Nicolini, D., Gherardi, S., & Yanow, D. (2003). *Knowing in organizations: A practice-based approach*. USA: M.A.Sharpe.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. New York, NY: Oxford University Press.

Nord, W. R., & Tucker, S. (1987). *Implementing routine and radical innovations*. Lexington, KY: Lexington Books.

Norwegian Oil Industry Association, OLF. (2002). Retrieved from www.olf.no

Norwegian Oil Industry Association, OLF. (2003). *E-drift på norsk sokkel – det tredje effektiviseringsspranget.*

Norwegian Oil Industry Association, OLF. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf.*

Norwegian Oil Industry Association, OLF. (2007). *Integrerte Operasjoner – Akselerert utvikling på norsk sokkel*.

Norwegian Petroleum Directorate (NPD). (2005). *Styringsgruppen for edrift.* Retrieved from http://www.npd.no/Norsk/Emner/IO/Styringsgruppen+for+Edriftforum/edriftforum_styringsgruppe_mandat.htm

Nylehn, B. (2002). *Prosjektorganisering. Teorigrunnlag og implikasjoner*. Bergen, Norway: Fagbokforlaget.

OG21 – Nasjonal Teknologistrategi. (2008). *Technology strategy for integrated operations and real time reservoir management.*

OLF Norwegian Oil Industry Association. (2005). *Integrated work processes: Future work processes on the Norwegian Continental Shelf*. Retrieved September 21, 2009, from http://www.olf.no/getfile.php/zKonvertert/www.olf.no/Rapporter/Dokumenter/051101%20Integrerte%20arbeidsprosesser,%20rapport.pdf

OLF. (2003). *eDrift på norsk sokkel – det tredje effektiviseringsspranget*. OLF-rapport.

OLF. (2003). *OLF Anbefalte retningslinjer for felles model for arbeidstillatelser (AT), rev. 2., nr. 088*. Norwegian Oil Industry Association.

OLF. (2006). *Verdipotenisalet for Integrete Operasjoner på Norsk Sokkel*. OLF-rapport.

OLF. (2007). *HMS og integrerte operasjoner: Forbedringsmuligheter og nodvendige tiltak*. Retrieved August 19, 2001, from http://www.ptil.no/getfile.php/PDF/IO%20og%20HMS-%20OLF-rapport.pdf

OLF. (2008). *Arena integrerte operasjoner – Smarte sanntidsoperasjoner for oljesktoren.* Retrieved August 19, 2011, from http://www.ncesubsea.no/publish_files/Jan_Krokeide_OLF.pdf

OLF. (2008). *Integrated operations in new projects, Draft version 0.2 Open for comments*. The Norwegian Oil Industry Association.

OLF. (2010). *Brochure integrated operations*. Retrieved January 15, 2011, from http://home.hit.no/~hansha/documents/theses/2010/BazeField/Background/Baze/Integrated_Operations_%20Brochure.pdf

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction*, *15*, 139–178. doi:10.1207/S15327051HCI1523_4

O'Reilly, T., & Battelle, J. (2009). *Web squared: Web 2.0 five years on*. Position paper for the Web 2.0 summit.

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science*, *3*(3), 398–427. doi:10.1287/orsc.3.3.398

Orlikowski, W. J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. *Organization Science*, *13*(3), 249–273. doi:10.1287/orsc.13.3.249.2776

Orlikowski, W. J. (2008). Sociomateriality: Challenging the separation of technology, work and organization. *The Academy of Management Annals*, *2*(1), 433–474. doi:10.1080/19416520802211644

Orlikowski, W. J. (2009). The sociomateriality of organizational life: Considering technology in management research. *Cambridge Journal of Economics*, *34*, 125–141. doi:10.1093/cje/bep058

Orr, J. E. (1996). *Talking about machines: An ethnography of a modern job*. Ithaca, NY: Cornell University Press.

Øxnevad, K. I. (2000). *The NPDT – The next generation concurrent design approach*. EUSEC 2000, 2nd European Systems Engineering Conference, September 13th – 15th 2000, Munich, Germany.

Pariol, J. (2011). Resilience and the ability to respond. In Hollnagel, E., Pariés, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice*. Farnham, UK: Ashgate.

Paulsen, G. (2005). *Informasjon over Nordsjøen: Telekommunikasjon på norsk sokkel.* Forskningsrapport 3/2005. Handelshøyskolen BI. Institutt for innovasjon og økonomisk organisering. Senter for næringslivshistorie.

Paulus, P. B., & Van der Zee, K. (2004). Should there be a romance between teams and groups? *Journal of Occupational and Organizational Psychology*, *77*, 475–480. doi:10.1348/0963179042596496

Pawlowski, S. D., & Robey, D. (2004). Bridging user organizations: Knowledge brokering and the work of information technology professionals. *Management Information Systems Quarterly*, *28*(4), 645–672.

Perrow, C. (1999). *Normal accidents: Living with high-risk technologies*. Princeton, NJ: Princeton University Press.

Philips, I. C., Critchley, C., Shaw, P., & Thomas, J. (2007, April). *SPE-106982: Deployment of advanced collaborative environments at scale in the North Sea operations.* Paper presented at the 2007 SPE Digital Energy Conference and Exhibition held in Houston, Texas, U.S.A.

Piderit, S. K. (2000). Rethinking resistance and recognizing ambivalence: A multidimensional view of attitudes toward an organizational change. *Academy of Management Review*, *25*(4).

Popham, M., & Edwards, T. (2009, April). *SPE-123096: What lessons can digital oil field practitioners learn from defence initiatives such as network enabled capability?* Paper presented at the SPE Digital Energy Conference & Exhibition held in Houston, Texas, U.S.A.

Porter, M. E. (1990). *The competitive advantage of nations*. London, UK: The Macmillan Press LTD.

Postholm, M. B. (2005). *Kvalitativ metode: En innføring med fokus på fenomenologi, etnografi og kasusstudier*. Oslo, Norway: Universitetsforlaget.

Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: A review of current literature and directions for future research. *ASM SIGMIS Database*, *35*(1), 6–36. doi:10.1145/968464.968467

Powell, W. W., & Grodal, S. (2005). Networks of innovators. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation*. Oxford, UK: Oxford University Press.

Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review*, (May): 1990.

Prøsch, K. (2010). *Forbedring i sikkerhet i kran og løft operasjoner basert på bedre samhandling i logistikkprosessen for brønn og boring*. Master Thesis in Marine Systems, NTNU.

PSA, Petroleum Safety Authority Norway. (2010). *Tilsynsaktivitet med Statoils planlegging av brønn 34/10-C-06A* (Gullfaks C) In Norwegian.

Raasen, B. (2008). *Tid for integrert handling*. Norwegian Petroleum Directorate.

Rasmussen, J. (1997). Risk management in a dynamic society: A modeling problem. *Safety Science*, *27*(2-3), 183–213. doi:10.1016/S0925-7535(97)00052-0

Rawdon, J. C. (2003, March). *SPE-80948: Collaboration in knowledge sharing.* Paper presented at the SPE Production and Operations Symposium held in Oklahoma City, Oklahoma, U.S.A.

Raymond, L., St-Pierre, J., Fabi, B., & Lacoursière, R. (2010). Strategic capabilities for the growth of manufacturing SMEs: A configurational perspective. *Journal of Developmental Entrepreneurship*, *15*(2), 123–142. doi:10.1142/S1084946710001476

Reason, J. (1997). *Managing the risks of organizational accidents*. Aldershot, UK: Ashgate.

Reger, R. K., Mullane, J. V., Gustafson, L. T., & DeMarie, S. M. (1994). Creating earthquakes to change organizational mindsets. *The Academy of Management Executive*, *8*(4), 31–43. doi:10.5465/AME.1994.9412071701

Reiman, T., & Oedewald, P. (2009) *Evaluating safety-critical organizations deEmphasis on the nuclear industry.* Swedish Radiation Safety Authority report no 2009:12

Reinertsen, D. G., & Smith, P. G. (1991). *The strategist's role in shorthening product development. The Journal of Business Strategy*. July/August.

Rindahl, G., Skjerve, A. B. M., Falmyr, O., Nilsen, S., Sarshar, S., Randem, H. O., & Braseth, A. O. (2009). *Studies on the effects on risk identification in team decision processes when applying risk visualisation technologies to support long and short term maintenance planning in future integrated operations in the petroleum sector*. White Paper No. P4.1-001:IO Center.

Rindahl, G., Skjerve, A. B., Sarshar, S., & Braseth, A. O. (2012). Risk informed decisions in future collaboration environments – Mapping of information and knowledge onto a shared surface to improve planner's risk identification. *Integrated operations: Risk, safety and resilience,* in press.

Rindahl, G., Torgersen, G.-E., Kaarstad, M., Drøivoldsmo, A., & Broberg, H. (2009). *IO collaboration and interaction at Brage. Collecting the features of successful collaboration that training, practices and technology must support in future integrated operations.* IO Center report Program 4.1-003-. Trondheim, Norway: NTNU.

Ringstad, A. J., & Andersen, K. (2006). Integrated operations and HSE – Major issues and strategies. Paper presented at the SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production (SPE 98530). Abu Dhabi, U.A.E., 2-4 April 2006.

Ringstad, A. J., & Andersen, K. (2007*). Integrated operations and the need for a balanced development of people, technology and organization*. Chapter presented at the International Petroleum Technology Conference, Dubai, UA.

Ringstad, H. E., Ødegård, T., Tidemann, A., Einarsen, L. A., & Thomsen, T. (2008). *The team compass: Team building with type understanding,* In Norwegian. Bergen, Norway: Optimas. Retrieved from http://www.optimas.no/team.htm

Roberts, K. H., & Bea, R. (2001). Must accidents happen? Lessons from high-reliability organizations. *The Academy of Management Executive*, *15*(3).

Robson, S. (2004, October). *SPE-88582: Alliancing and partnerships: What we have learned and where we are going.* Paper presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition, Perth, Australia.

Rogers, E. M. (2003). *Diffusion of innovations*. New York, NY: Free Press.

Rollenhagen, C. (1997). *Sambanden människa, teknik och organisation - en introduktion* (second reprint). Lund, Sverige: Utbildningshuset, Studentlitteratur.

Rosendahl, T., & Egir, A. (2008). Multidisiplinære team og oljeindustrien – Hvordan implementere Concurrent Design i StatoilHydro? *Magma (New York, N.Y.)*, 6.

Rosenthal, U., & Hart, P. (1991). Experts and decision makers in crisis situation. *Knowledge: Creation, Diffusion. Utilization*, *12*(4), 350–372.

Rosness, R. (2001). *Lean and vulnerable? About the value of organizational redundancy.* (In Norwegian) SINTEF Report STF38 A01413, Trondheim.

Rosness, R., Håkonsen, G., Steiro, T., & Tinmannsvik, R. K. (2000). *The vulnerable robustness of high reliability organisations: A case study report from an offshore oil production platform*. Paper presented at the 18th ESReDA seminar Risk Management and Human Reliability in Social Context Karlstad, Sweden, June 15 - 16, 2000.

Rosness, R. (2002). Slank og sårbar? In Forseth, U., & Rasmussen, B. (Eds.), *Arbeid for livet. Oslo, Norway*. Gyldendal Norsk Forlag, AS.

Rostand, A., & Soupa, O. (2011). Benchmark survey reveals looming talent shortage. *E&P Magazine.* Retrieved August 15, 2011, from http://www.epmag.com/Magazine/2011/5/item81982.php

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Journal*, *23*(3), 393–404. doi:10.5465/AMR.1998.926617

Røvik, K. A. (1998). *Moderne Organisasjoner. Trender i organisasjonstenkingen ved tusenårsskiftet*. Bergen, Norway: Fagbokforlaget.

Røvik, K. A. (2007). *Trender og Translasjoner – Idéer som former det 21. århundrets organisasjon*. Oslo, Norway: Universitetsforlaget.

Rubin, H. J., & Rubin, I. (1995). *Qualitative interviewing: The art of hearing data*. Thousand Oaks, CA: Sage.

Russo, E. E. R., et al. (2010). *Benefits quantification and change management in Petrobras corporate program for digital integrated field management (GeDIg)*. Paper presented at the Intelligent Energy Conference, SPE 128675-MS.

Ryle, G. (1949). *The concept of mind*. London, UK: Hutchinson.

Saggaf, M. M. (2008). A vision for future upstream petroleum technologies. *Journal of Petroleum Technology*, *53-55*, 94–98.

Sagli, J. R., Klumpen, H. E., Nunez, G., & Nielsen, F. (2007, November). *Improved production and process optimization through people, technology, and process.* Anaheim, CA: SPE Annual Technical Conference and Exhibition.

Salaman, G., & Asch, D. (2003). *Strategy and capability. Sustaining organizational change*. Malden, MA: Blackwell Publishing.

Salas, E., Rosen, M. A., Burke, C. S., & Goodwin, G. F. (2009). The wisdom of collectives in organizations: An update of the teamwork competencies. In Salas, E., Goodwin, G. F., & Burke, C. S. (Eds.), *Team effectiveness in complex organization. Cross-disciplinary perspectives and approaches*. New York, NY: Routledge.

Salas, E., Sims, D., & Burke, C. S. (2005). Is there a "big five" in teamwork? *Small Group Research*, *36*, 555–599. doi:10.1177/1046496405277134

Salerno, A., & Brock, L. (2008). *The change cycle: How people can survive and thrive in organizational change*. Williston, ND: Berrett-Koehler Publishers.

Sandelands, L. E., & Boudens, C. J. (2000). Feelings at work. In Fineman, S. (Ed.), *Emotions in organizations*. London, UK: Sage Publications Ltd. doi:10.4135/9781446219850.n3

Sarshar, S., & Sand, T. (2010). Communicating risk in planning activities distributed in time. In *Proceedings of Risk, Reliability and Societal Safety*, ESREL 2010, September 5-9, Rhodes, Greece, (pp. 2033-2038).

Sarshar, S., Sand, T., Skjerve, A. B., Rindahl, G., & Hermansen, B. (2011). Quality aspects in planning of maintenance and modifications on offshore oil and gas installations. In Bérenguer, C., Grall, A., & Soares, C. G. (Eds.), *Advances in safety, reliability, and risk management*. CRC Press. doi:10.1201/b11433-245

Sartika, Y., & Suwardi, I. (2007). Generic expert system – Incremental learning system. *International Conference on Electrical Engineering and Informatics* (pp. 564-566). Bandung, Indonesia: Institut Teknologi Bandung.

Schiefloe, P. M., & Mauseth Vikland, K. (2005). *Årsaksanalyse etter Snorre A hendelsen 28.11.2004*. Stavanger, Norway: Statoil.

Schreyogg, G., & Kliesh-Eberl, M. (2007). How dynamic can organizational capabilities be? Towards a dual-process model of capability dynamization. *Strategic Management Journal*, *28*(9), 913–933. doi:10.1002/smj.613

Schumpeter, J. (1934). *The theory of economic development*. Cambridge, MA: Harvard University Press.

Scott Armstrong, J. (1980). The seer-sucker theory: the value of experts in forecasting. *Technology Review*, *82*(7), 16–24. Retrieved from http://works.bepress.com/j_scott_armstrong/1

Senge, P. M. (1990). *The fifth discipline: Art and practice of the learning organization*. New York, NY: Doubleday.

Sennett, R. (1998). *The corrosion of character. The personal consequences of work in the new capitalism.*

Shannon, C., & Weaver, W. (1949). *The mathematical theory of communications*. Urbana, IL: University of Illinois Press.

Shanteau, J. (2001). What does it mean when experts disagree? In Salas, E., & Klein, G. (Eds.), *Linking expertise and naturalistic decision making*. Mahwah, NJ: Lawrence Erlbaum Associates.

Sharp, J. M., Belohoubek, P., Castka, P., & Bamber, C. J. (2001). Factors affecting successful implementation of high performance teams. *Team Performance Management*, *7*(7-8), 123–134.

Shuen, A. (2008). *Web 2.0: A strategy guide*. O'Reilly.

Shuffler, M. L., Wiese, C. W., Salas, E., & Burke, C. S. (2010). Leading one another across time and space: Exploring shared leadership functions in virtual teams. *Revista de Psicologia y de las Organizaciones*, *26*, 3–17. doi:10.5093/tr2010v26n1a1

Simon, H., & March, J. G. (1958). *Organizations*. New York, NY: John Wiley and sons, Inc.

Skarholt, K., Hansson, L., Antonsen, S., & Hermundsgård, M. (2011). *Felles driftsmodell i Statoil: Hva er HMS-konsekvensene? (Common operation model in Statoil: What are the consequences for HSE?)* SINTEF report F18858.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. B. (2009). Integrated operations and leadership – How virtual cooperation influences leadership practice. In Martorell, S. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications*. London, UK: Taylor & Francis Group.

Skarholt, K., Næsje, P., Hepsø, V., & Bye, A. S. (2009). Empowering operations and maintenance: Safe operations with the 'one directed team' organizational model at the Kristin asset. In Martorell, S., Soares, C. G., & Barnett, J. (Eds.), *Safety, reliability and risk analysis: Theory, methods and applications* (pp. 1407–1414). London, UK: Taylor & Francis Group.

Skarholt, K., & Torvatn, H. (2010). Trust and safety culture: The importance of trust relations in integrated operations (IO) in the Norwegian oil industry. In Bris, R., Guedes Soares, C., & Martorell, S. (Eds.), *Reliability, risk and safety: Theory and applications* (*Vol. 2*, pp. 1285–1291). London, UK: Taylor & Francis Group.

Skjerve, A. B. (2008). Robust arbeidspraksis (Robust work practice). In R. Tinmannsvik (Ed.), *Robust arbeidspraksis - hvorfor skjer det ikke flere ulykker på sokkelen?* (*Robust work practice – why doesn't more accidents occur on the continental shelf?)* Trondheim, Norway: Tapir Akademisk forlag.

Skjerve, A. B., & Rindahl, G. (2010). *Promoting trust between members of distributed teams. Lessons learned from an exploratory study in the petroleum industry*. Paper presented at the 2010 IEEE International Conference on Systems, Man, and Cybernetics, 10-13, October 2010, Istanbul, Turkey.

Skjerve, A. B., & Torgersen, G. E. (2007). *An organizational-pedagogical framework to support competence assurance activities*. Paper, ESREL (European Safety and Reliability Association) Conference 2007, 25-27 June, Stavanger.

Skjerve, A. B., Albrechtsen, E., & Tveiten, C. K. (2008). *Defined situations of hazard and accident related to integrated operations on the Norwegian Continental Shelf.* Report no. NTNU/SINTEF/IFE – Program 4.3- Report no. SINTEF A9123 –2008.12.22. Open.

Skjerve, A. B., Rindahl, G., Randem, H. O., & Sarshar, S. (2009). *Facilitating adequate prioritization of safety goals in distributed teams at the Norwegian Continental Shelf.* Paper presented at the 17th Congress of the International Ergonomics Association, August 9-14, 2009, Beijing, China.

Skjerve, A. B., Sarshar, S., Rindahl, G., Braseth, A. O., Randem, H. O., Fallmyr, O., Sand, T., & Tveiten, C. (2011). *The integrated operations maintenance and modification planner (IO-MAP). The first usability evaluation – Study and first findings*. Center for Integrated Operations in the Petroleum Industry IO Center Program 4: Report no: IFE/HR/F-2011/1491, Halden, Norway: Institutt for energitekk.

Smith, P. G., & Reinertsen, D. G. (1991). *Shortening the product development cycle. Research-Technology Management*. May/June.

Smith, R. P., & Eppinger, S. D. (1997). A predictive model of sequential iteration in engineering design. *Management Science*, *43*(8), 1104–1120. doi:10.1287/mnsc.43.8.1104

Snook, S. C. (2000). *Friendly fire: The accidental shoot down of U.S. Black Hawks over Northern Iraq*. Princeton, NJ: Princeton University Press.

SSB. (2007). *Financial results on the Norwegian Continental Shelf 1989-2007*. Retrieved August 26, 2011, from http://www.ssb.no/english/subjects/10/06/20/oljeregn_en/

Stadtler, H., & Kilger, C. (Eds.). (2008). *Supply chain management and advanced planning*. Berlin, Germany: Springer-Verlag. doi:10.1007/978-3-540-74512-9

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, *19*, 387–420. doi:10.1177/030631289019003001

Statoil. (2005). *Annual report and accounts 2005*.

Statoil. (2010). *Intern granskningsrapport. Brønnhendelse på Gullfaks C* (04.11.10). In Norwegian [Internal investigation report, Gullfaks C].

Statoil. (n.d.). *Facts: Integrated operations.* Retrieved from http://www.statoil.com/en/NewsAndMedia/Multimedia/features/Pages/FactsAboutIO.aspx

Statoil. (n.d.). *Home page* (in Norwegian). Retrieved from www.statoil.com/no

StatoilHydro. (2007). Integrated operations in StatoilHydro. *Monthly Newsletter*, May 2007.

Steffensen, J., & Bremdal, B. A. (2006) *In what way does corporate knowledge hold the key to future success?* White Paper on Hydro Aluminimums Business, Vækerø, Oslo 2006.

Steinkuehler, C. A. (2004). Learning in massively multiplayer online games. *Proceedings of the 6th International Conference on Learning Sciences*, (pp. 521-528).

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *The Journal of Communication*, *42*(4), 73–93. doi:10.1111/j.1460-2466.1992.tb00812.x

Storey, N. (1996). *Safety-critical computer systems*. Harlow, UK: Pearson Education Limited.

Stortingsmelding 7. (2001- 2002). *Om helse., miljø og sikkerhet i petroleumsvirksomheten. Arbeids- og Administrasjonsdepartementet* [Parliament Proposition number 7. 2001-2002, On Health Safety and Environment in the Petroleum Industry]. Retrieved from http://odin.dep.no/mod/norsk/dok/reg.publ/stmeld/002001-040012/hov001-bn.html

Strasunskas, D., & Tomasgard, A. (2009). *In quest of ICT value through integrated operations: Assessment of organizational – technological capabilities.* IO centre home page.

Strickland, L. H. (1958). Surveillance and trust. *Journal of Personality*, *26*(2), 200–215. doi:10.1111/j.1467-6494.1958.tb01580.x

Stundner, M., Nunez, G., & Møller Nielsen, F. (2008, February). *From data monitoring to performance monitoring.* Amsterdam, The Netherlands: SPE Intelligent Energy Conference and Exhibition.

Suchman, L. A. (2007). *Human-machine reconfigurations. Plans and situated actions*. Cambridge, UK: Cambridge University Press.

Sunstein, C. R. (2004). *Group judgments: Deliberation, statistical means, and information markets*. U. Chicago John M. Olin Law & Economics Working Paper No. 219 (2nd Series). Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=578301

Surowiecki, J. (2004). *The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business, economies, societies and nations*. London, UK: Little Brown Book.

Sutton, R. (1996). Generalization in reinforcement learning: Successful examples using sparse coarse coding. *Advances in Neural Information Processing Systems*, *8*, 1038–1044.

Takeuchi, H., & Nonaka, I. (1986). The new product development game. *Harvard Business Review*, (n.d), 1.

Taylor, D., & Fosse, K. (2006, February). *SPE 100704: Collaborative decision making in operations-centre environments*. Paper presented at the SPE Intelligent Energy Conference, Amsterdam, Netherlands.

Tealdi, L., Kreft, E., & Donachie, J. M. (2006, April). *SPE-99924: Developing young exploration and production professionals to solve the "big crew change"*. Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Teece, D. J., & Pisano, G. (1994). The dynamic capabilities of firms. An introduction. *Industrial and Corporate Change*, *3*(3), 537–556. doi:10.1093/icc/3.3.537-a

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533. doi:10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

The Centre for Integrated Operations in the Oil and Gas Industry. (2011). *Website*. Retrieved August 25, 2011, from http://www.ntnu.edu/iocenter

The Norwegian Ministry of Petroleum and Energy. (2004). *St.meld. nr. 38* (2003-2004). Oslo, Norway: Om petroleumsvirksomheten.

The, U. S. Government Accountability Office. (n.d.). *BPR glossary of terms*. Retrieved from http://www.gao.gov/special.pubs/bprag/bprgloss.htm

Thompson, G., & Li, J. Z. (2010). *Leadership. In search of effective influence strategies*. Oslo, Norway: Gyldendal Akademisk.

Tilton, D., Lyttinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(5).

Tinmannsvik, R. K., Albrechtsen, E., Bråtveit, M., Carlsen, I. M., Fylling, I., Hauge, S., … Øien, K. (2011). *Deepwater Horizon-ulykken: Årsaker, lærepunkter og forbedringstiltak for norsk sokkel.* [In Norwegian]. SINTEF report no A19148.

Toffler, A. (1985). *Fremtidsglimt* [Future glimpse]. København, Denmark: Chr. Erichsen.

Torgersen, G. E. (2008). The idea of a military pedagogical doctrine. In T. Kvernbekk, H. Simpson, & M. A. Peters (Eds.), (2008). *Military pedagogies. And why they matter*. Rotterdam, The Netherlands: Sense Publishers.

Torgersen, G. E., & Steiro, T. J. (2010). *Interaction in complex organisations*. IMTA Conference, September 27 – October 1, 2010. Lucerne, Switzerland.

Torgersen, G. E., & Skjerve, A. B. (2012). *Towards an IO pedagogy. Paper, project/work in progress. Institute for Energy Technology (IFE)*. Halden.

Torgersen, G. E., & Steiro, T. J. (2009). *Ledelse, samhandling og opplæring i fleksible organisasjoner* [Leadership, Interaction and Training in Flexible Organizations]. Stjørdal, Norway: Læringsforlaget.

Treat, J. E. (Ed.). (1994). *Creating the high performance international petroleum company: Dinosaurs can fly*. Tulsa, Oklahoma: PennWell.

Tsoukas, H. (2005). *Complex knowledge: Studies in organizational epistemology*. New York, NY: Oxford University Press.

Turner, B. A., & Pidgeon, N. F. (1997). *Man-made disasters* (2nd ed.). London, UK: Butterworth-Heinemann.

Tveiten, C. K., Albrechtsen, E., Wærø, I., & Wahl, A. M. (2010). *Building resilience into emergency management*. Paper presented at Workingonsafety.net 2010.

Tye, B. (2010, March), *SPE-129112: Unconventional hydrocarbons: Intelligent integration and operation.* Paper presented at the SPE Intelligent Energy Conference and Exhibition, Utrecht, The Netherlands.

Upstream Technology. (February 2007). *Interview with Adolfo Henriquez, manager – Corporate initiative integrated operations, StatoilHydro* (pp. 36-37).

van den Berg, F. (2007, April), *SPE-108206: Smart fields – Optimizing existing fields*. Paper presented at the SPE Digital Energy Conference and Exhibition held in Houston, Texas, U.S.A.

Van der Vegt, G., & Bunderson, J. S. (2005). Learning and performance in multi-disciplinary teams: The importance of collective team identification. *Academy of Management Journal*, *48*(3), 532–547. doi:10.5465/AMJ.2005.17407918

Van der Vegt, G., & Van der Vliert, E. (2000). Team members' affective responses to patterns of intragroup interdependence and job complexity. *Journal of Management*, *26*(4), 633–655.

Van Gerven, M. (2007, September). *Bayesian networks for clinical decision support: A rational approach to dynamic decision-making under uncertainty*. SIKS Dissertation Series. Retrieved November 20, 2011, from http://dare.ubn.kun.nl/bitstream/2066/30201/1/30201_bayenefoc.pdf

Veland, Ø., & Andresen, G. (2011). *Scenario composer. A collaborative planning tool for offshore petroleum operations*. Poster at the 7th International Conference on Integrated Operations in the Petroleum Industry, Trondheim, Norway September 13-14.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four Longitudinal field studies. *Management Science*, *46*(2), 186–204. doi:10.1287/mnsc.46.2.186.11926

Verkerk, M. J. (2004). *Trust and power on the shop floor: An etnographical, ethical and philosophical study on responsible behaviour in industrial organizations*. Delft, The Netherlands: Eburon Academic Publishers.

Vindasius, J. (2008, February). *SPE-112218: The integrated collaboration environment as a platform for new ways of working: Lessons learned from recent projects*. Paper presented at the SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands.

Volberda, H. W. (1999). *Building the flexible firm: How to remain competitive*. Oxford, UK: Oxford University Press. doi:10.1093/acprof:oso/9780198295952.001.0001

von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation. How to unlock the mystery of tacit knowledge and release the power of innovation*. New York, NY: Oxford University Press.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, *22*(2), 195–219. doi:10.1108/01443570210414329

Voydanoff, P., & Donnelly, B. W. (1999). Multiple roles and psychological distress: The intersection of the paid worker, spouse, and parent roles with the role of the adult child. *Journal of Marriage and the Family*, *61*(3), 725–738. doi:10.2307/353573

Wahlen, M., Landmark, T., Sandven, K., Høydalsvik, H., & Hellebust, A. (2005). *Utredning om konsekvenser av omfattende innføring av edrift (integrerte operasjoner) på norsk sokkel for arbeidstakerne i petroleumsnæringen og muligheter for utvikling av nye norske arbeidsplasser*. SINTEF.

Walumbwa, F. O., Avolio, B. J., & Hartnell, C. (2010). Transformational leadership theories. In Levine, J., & Hogg, M. A. (Eds.), *Encyclopedia of group processes and intergroup relations*. Thousand Oaks, CA: Sage.

Webster's Online Dictionary. (2011). *Commitment*. Retrieved July 2. 2011 from http://www.websters-online-dictionary.org/definitions/Commitment

Weeks, M. (2009). Sourcing practices and innovation: Evidence from the auto industry on the sourcing relationship as a dynamic capability. *Innovation: Management. Policy & Practice*, *11*(3), 304–326. doi:10.5172/impp.11.3.304

Weick, K. E. (1987). Organization culture as a source of high reliability. *California Management Review*, *29*, 116–136.

Weick, K. E., & Sutcliffe, K. M. (2007). *Managing the unexpected, resilient performance in an age of uncertainty* (2nd ed.). San Francisco, CA: John Wiley & Sons, Inc.

Weiss, J., & Hughes, J. (2011). Want collaboration? Accept and actively manage conflict. *Harvard Business Review*, (3): 65–92.

Weltzien, A. (2011). *Resilience in well operations through use of collaboration technology.* Master thesis at NTNU.

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems Thinker, 9*(5).

Wenger, E. (2000). Communities of practice and social learning systems. *Organization*, *7*, 225–246. doi:10.1177/135050840072002

Wenger, E. C., McDermott, R., & Snyder, M. W. (2002). *Cultivating communities of practice*. Boston, MA: Harvard Business School Press.

West, M. A., & Slater, J. A. (1995). *Teamwork: Myths, realities and research*. Occupational Psychology, Institute of Work Psychology, University of Sheffield, April 1995, 24-29

West, M. A., Hirst, G., Richter, A., & Shipton, H. (2004). Twelve steps to heaven: Successfully managing change through developing innovative teams. *European Journal of Work and Organizational Psychology*, *13*(2), 269–299. doi:10.1080/13594320444000092

Whittington, R., & Mayer, M. (2002). *Organizing for success in the twenty-first century: A starting point for change*. London, UK: Chartered Institute of Personnel and Development.

Wickens, C. D. (1992). *Engineering psychology and human performance* (2nd ed.). New York, NY: HarperCollins.

Wikipedia. (n.d.). *Forward compatible*. Retrieved from http://en.wikipedia.org/wiki/Forward_compatible

Wikipedia. (n.d.). *Integrated operations*. Retrieved from http://en.wikipedia.org/wiki/Integrated_operations

Williams, P. (2006). *How collaborative environments influence culture & behaviour*. Presented at the SPE Intelligent Energy, Amsterdam

Woods, D. D. (2005). Creating foresight: Lessons for enhancing resilience from Columbia. In Starbuck, W. H., & Farjoun, M. (Eds.), *Organization at the limit. Lessons from the Columbia disaster*. Oxford, UK: Blackwell Publishing.

Woods, D. D. (2006). Essential characteristics of resilience. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Woods, D. D., & Hollnagel, E. (2006). Prologue: Resilience engineering concepts. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Woodward, J. (1965). *Industrial organization: Theory and practice*. London, UK: Oxford University Press.

Woolf, P. (2009). Bayesian networks I - Static models and multinomial distributions. *Chemical Process Dynamics and Control*. Retrieved November 20, 2011, from https://controls.engin.umich.edu/wiki/images/d/da/Lecture.26.pdf

Wreathall, J. (2006). Properties of resilient organizations: An initial view. In Hollnagel, E., Woods, D. D., & Leveson, N. (Eds.), *Resilience engineering. Concepts and precepts*. Aldershot, UK: Ashgate.

Wreathall, J. (2011). Monitoring – A critical ability in resilience engineering. In Hollnagel, E., Pariés, J., Woods, D. D., & Wreathall, J. (Eds.), *Resilience engineering in practice*.

Yawanarajah, S., Williams, J., Carrell, K., Webb, T., & Cox, M. (2008, November). *SPE-118128: Improving life control loop project delivery through better decision-making under uncertainty.* Paper presented at the SPE 2008 Abu Dhabi International Petroleum Exhibition and Conference, Abu Dhabi, U.A.E.

Yin, R. (Ed.). (2004). *The case study anthology*. Thousand Oaks, CA: Sage Publications Inc.

Yin, R. K. (2002). *Case study research: Design and methods* (3rd ed., *Vol. 5*). Sage Applied Social Research Method Series.

Yin, R. K. (2009). *Case study research: Design and methods*. Los Angeles, CA: Sage.

Yoo, Y., Hendridsson, O., & Lyytinen, K. (2010). The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(5).

Yukl, G. (1989). Managerial leadership: A review of theory and research. *Journal of Management*, *15*(2), 251–289. doi:10.1177/014920638901500207

Yukl, G. (2010). *Leadership in organizations*. Upper Saddle River, NJ: Pearson.

Zaltman, G., Duncan, R., & Holbek, J. (1973). *Innovation and organizations*. New York, NY: John Wiley and Sons.

Zand, D. (1997). *The leadership trial: Knowledge, trust and power*. New York, NY: Oxford University Press.

Zangl, G., Al-Kinani, A., & Stundner, M. (2011). *Holistic workflow for autonomous history matching using intelligent agents: A conceptual approach.* SPE Digital Energy Conference and Exhibition.

Zangl, G., & Hannerer, J. (2003). *Data mining applications in the petroleum industry*. Katy, TX: Round Oak Publishing.

Zittrain, J. (2008). *The future of the Internet*. New Haven, CT: Yale University Press.

Zonooz, B. H., Farzam, V., Satarifar, M., & Bakhshi, L. (2011). The relationship between knowledge transfer and competitiveness in "SMES" with emphasis on absorptive capacity and combinative capabilities. *International Business and Management*, *2*(1), 59–85.

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INDEX

Index Terms **Links**

A

Acteur Network Theory 141
action phase 105 108
Actor Network Theory approach (ANT) 143
Advantage Real-time Engineer (ARTE) 217

B

Baker Expert Advisory Centre Operation Network (BEACON) 213
Bayesian Networks 269
Big Crew Change 60 71 263 281
boundary objects 185
boundary spanning 80
brownfield assests 68
Business intelligence (BI) 266
business operations niche 10
business process reengineering 178

C

Cambridge Energy Research Associates (CERA) 237
capability thinking 248
CAPEX 226
central control room (CCR) 81
central team asset 94
Centre for Integrated Operations (CIO) 307
champion role 136
Change Management (CM) 44
coagency 346
collaboration 184
Collaboration Complexity Profile (CCP) 48
collaboration conditions 48
collaboration niche 10

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
collaboration tools and software	4	42	80	
Collaborative work environments (CWEs)	59	62	113	
co-location	310			
combination	61	75	85	97
	118	125	177	184
	191	193	196	221
	223	265	268	270
	273	276	353	362
	374			
Combined Operations	331			
commitment	183			
communities of practice	88	144	149	190
	249	252	255	260
	372	383	387	
competence	181			
complex teams	157			
concept of team	94			
concurrent design	156	159		
Concurrent Learning in Interaction (CLI)	335			
continuous learning	185			
CoPilot	218			
core operational capabilities	13			
cross-organizational collaboration	137			

D

data	264			
Data Acquisition Real Time (DART)	215			
data logs	359			
data utilization	125			
Deepwater Horizon accident	354			
Drill Stem Test (DST)	231			
duostrøm	148			

E

edge organization	78			
Eigendynamik	22			
emergency management room (EMR)	347			
employee commitment	287	299		

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
employee involvement	287			
European Space Agency (ESA)	160			
executive committee	241			
Extensible Marup Language (XML)	19			
externalization	265			
F				
Fabricom	247			
failure-free performance	373	377		
Failure Mode and Effects Analysis (FMEA)	346			
fibre-optic cable	124			
Field Development Planning	61			
fit dependency	79			
flexibility	332			
flow dependency	79			
frame conditions	48			
Front End Load (FEL)	231			
G				
Generation 0 (G-0)	43			
Generation 2 (G-2)	43			
glocal workplace	145			
greenfield assets	68			
H				
Hackman’s six elements of organization				
adequate resources	155	162		
clear targets	162			
regular feedback	162	164		
reliable information	162	164		
technical support	84	112	162	165
	213	218	252	
training	16	36	38	47
	56	66	83	119
	121	125	157	162
	164	167	182	184

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
Hackman's six elements of organization (*Cont.*)				
	187	193	199	209
	218	220	222	239
	258	268	272	293
	296	306	311	316
	329	331	335	340
	354	366		
hand-held device	249			
Hazard and operability Study (HAZOP)	346			
Health, Safety and Environment (HSE)	34			
heterogeneous engineering	144			
High-reliability organization (HRO)	372			
human resources (HR)	376			

I

information	264			
Information and Communication Technology (ICT)	19	40	49	53
	57	87	90	143
	148	151	171	176
	182	186	188	215
	254	257	298	329
	371	376		
information ecology	4			
information niche	10			
Information Technology (IT)	263			
Institute for Energy Technology (IFE)	196	340		
insulation, scaffolding, and surface treatment (ISS)	175			
Integrated Operations in Petrobras (GIOp)	226			
Integrated Operations (IO)	21	39	58	90
	103	141	156	172
	247	285	305	328
	332	342	370	
Integrated Planning (IPL)	171			
intelligent energy (iE)	38	70	121	123
	189	209	259	
intelligent infrastructure	10			
intention-based leadership	111			
interaction	345			

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
internalization	265			
IO-CENTER at NTNU	196			
IO design	142			
IO Maintenance and modification Planner (IOMAP)	193			
IO Mindset	41			
IO teamwork	104			
J				
joint cognitive system	346			
Joint Operations	331			
just in time (JIT)	344			
K				
Key Performance Indicators (KPI's)	52			
knowledge	264			
knowledge markets	306			
knowledge sharing	77			
knowledge sharing and analystics layer	10			
Knowledge Technology	263			
Kotter's 8-Stage Model of Change	290			
L				
leadership of IO teams	104			
leader-subordinate interaction	105			
leader-team interaction	106			
local team	93			
lucky shots	280			
M				
maintenance and modification planning	191	193	196	208
Man, Technology and Organizational (MTO)	49			
matrix management	119			
measured pressure drilling (MPD)	355			
meeting leader	116			
Microsoft Project™	197			
mindfulness	374	380		
M/LWD (Measurement	216			

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
mobile offshore units	129	134		
Montara accident	355			
multi-disciplinary team	94			
multiteam systems (MTS)	119			
N				
National Aeronautics and Space Administration (NASA)	160			
Network Centric Warfare	331	338		
Non-Productive Time (NPT)	214			
Norwegian continental shelf (NCS)	27	124	192	286
O				
OLE for process control (OPC)	4	19		
Onshore Inspection Center (OIC)	51			
onshore process plant	13			
On the Job Training (OJT)	218	223		
open office landscapes	132			
operational committee	241			
Operational Control Center (OCC)	229			
Operational support rooms (OPS)	141			
operations and mainternance (O&M)	112			
operatnig unit	64			
OPEX	226			
organizational change	157			
organizational code	309			
organizational learning	309			
organizational recipes	128			
organizational redundancy	373			
organizational resilience	371			
P				
padda	148			
peer influence	313			
People, Process, Technology and Organization (PPTO)	61			
People Process Technology (PPT)	61			

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
performance quality	200			
performance variability	357			
petroleum technology (PETEK)	82			
petrotechnical professionals	263			
platform drilling	129	131	137	
post-bureaucratic organizations	179			
post run analysis	361			
potential production loss	200	206		
pragmatic ignorance	348			
Pre-Salt Layer	226			
Pressure and temperature sensor (P/T)	19	38	43	57
	61	63	66	69
	88	96	99	104
	112	116	119	137
	139	152	168	173
	189	192	196	209
	214	226	229	237
	240	259	269	282
	287	290	298	300
	303	308	325	338
	343	351	368	386
Process, People, Technology and Organisation	172			
Production Markup Language (PRODML)	4	19		
Production Optimization	27	61	63	68
	81	84	87	100
	104	113	243	263
	282			
Programmable Logic Controller (PLC)	228			
PUB-10	228			

Q

quality, health, safety and environment (QHSE)	376	380		

R

real-time link	250			
Real-Time Operations	61	63	68	240
re-manning	214			
Remote Control Rooms (SCR)	229			

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
reservoir management	264			
Reservoir Navigation Service (RNS)	218			
resilient sub-capabilities	363			
anticipation	231	234	360	363
	365	373	380	
learning	1	6	18	24
	47	63	69	71
	75	77	88	114
	123	136	153	165
	169	180	182	185
	202	209	216	219
	221	224	237	248
	259	264	267	271
	277	282	299	302
	304	312	316	322
	326	330	335	357
	360	363	372	375
	381	383	386	
monitoring	3	10	51	70
	80	125	130	133
	168	213	218	221
	226	231	240	243
	245	264	268	283
	298	312	317	321
	356	358	363	365
	369	371	383	
response	29	52	54	79
	92	107	119	122
	131	200	206	218
	316	330	347	356
	361	363	374	381
resistance to change	45	118	285	288
	296	299	301	303
economic threats	288			
loss of status and power	288			
resentment of interference	289			
unnecessary beliefs	288			
rhythm creation	382			

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
rig visualization tool	132			
role assignment	318			
S				
Safe Job Analyses (SJA)	202			
safety culture	24	29		
safety hazard	200	202	206	
Safety-I	350			
Safety-II	350			
safety management	23	38	343	354
	356	362	366	372
	386			
safety performance	24	36		
Safran Planner ™	197			
Samhandling	333			
SAP™	197			
Science and Technology Studies (STS)	141	143		
seer-sucker theory	311	326		
self-synchronization	79			
shared leadership	106			
shared situational awareness	25			
perception	25	35		
prediction	25	35		
understanding	25	35		
sharing dependency	79			
short-term efficiency	373			
situational awareness	25	94	248	258
	374			
situational leadership	119			
smart oil field	61			
Snorre A near-accident	355	357		
social field	22			
IO field	22			
offshore	22			
onshore	22			
socialization	265	306	308	313
	317			
sosio-material approach	254			

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links			
Statfjord field	158			
statistical group	318			
Statoil	155			
status quo	290			
steering committee	52	131	241	
strategic context	382			
Structured Observation and Feedback in Integrated Operations (SOFIO)	337			
subsea pipeline	13			
subsurface pipeline	13			
subsurface team	94			
Surface Logging Systems (SLS or mudlogging)	216			
synchronization	79			
System Usability Scale (SUS)	200	207		
T				
tag	19			
taskwork-related competencies	65			
team adaptability	107	109	111	113
	122			
team behaviour	95			
team compositions	48			
team identity	100			
team purpose	95			
team size	95			
team skill	95			
teamwork-related competencies	65			
Technology Acceptance in Integrated Operations (TAM-IO)	48			
Technology Acceptance Model (TAM)	49			
technology division	130	132	134	
technology resource layer	10			
telecooperation-related competencies	65			
theory of reasoned action (TRA)	49			
time gap	251			
transformational leadership	25	119		
transition phase	105	118		
transparency	373	377		

This page has been reformatted by Knovel to provide easier navigation.

Index Terms	Links		
U			
understanding	265		
unified architecture (UA)	4	19	
unified communication platforms (UCP)	145		
V			
virtual team	96	98	102
visualization technology	193		
W			
Wanda Orlikowski	248		
wanton ignorance	349		
Water Alternate Gas (WAG)	232		
Well and Reservoir Management	61	68	114
Why-, What- and How- (WWH-)	308		
wisdom	265		
wisdom of crowds	305	327	
X			
XT	10		

This page has been reformatted by Knovel to provide easier navigation.