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Enterprise-Control System Integration
– Part 2: Object Model Attributes

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Enterprise-Control System Integration – Part 2: Object Model Attributes

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 2: Objects model attributes

FOREWORD

This standard is Part 2 of a multi-part set of standards that defines the interfaces between enterprise activities and control activities. It follows ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod), Enterprise-Control System Integration - Part 1: Models and Terminology.

The scope of this Part 2 standard is limited to defining the details of the interface content between manufacturing control functions and other enterprise functions. The scope of this Part 2 standard is limited to the definition of object models and attributes for the information defined in Part 1. The goal is to reduce the effort, cost, and errors associated with implementing these interfaces.

The standard may be used to reduce the effort associated with implementing new product offerings. The goal is to have enterprise systems and control systems that interoperate and easily integrate.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2. Therefore, the first three clauses present the scope of the standard, normative references, and definitions, in that order.

Clause 4 is informative. It describes the general information about the object models and examples defined in later clauses.

Clause 5 is normative. It defines the object models and attributes of common information defined in Part 1.

Clause 6 is normative. It defines the object models and attributes of operations management information defined in Part 1.

Clause 7 is informative. It defines the inter-relationships between the object models.

Clause 8 is informative. It lists the objects defined in the standard as an aid to documenting conformance and compliance.

Clause 9 is normative. It defines completeness, conformance and compliance criteria associated with the objects and attributes.

Annex A is normative. It defines the object models and attributes of production specific information defined in Part 1.

Annex B is informative. It provides examples to illustrate how the models and attributes may be used.

Annex C is informative. It illustrates some example data sets.

Annex D is informative. It contains questions and answers on the use and reason for elements in the standard.

Annex E is informative. It discusses how the standard relates to logical information flows.

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INTRODUCTION

This Part 2 standard further defines formal object models for exchange information described in ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod), Enterprise- Control System Integration - Part 1: Models and Terminology (hereafter referred to as Part 1) using UML object models, tables of attributes, and examples. The models and terminology defined in this part:

- a) emphasize good integration practices of control systems with enterprise systems during the entire life cycle of the systems;
- b) can be used to improve existing integration capability of manufacturing control systems with enterprise systems; and
- c) can be applied regardless of the degree of automation.

Specifically, this part provide a standard terminology and a consistent set of concepts and models for integrating control systems with enterprise systems that will improve communications between all parties involved. Benefits produced will

- a) reduce the user's time to reach full production levels for new products;
- b) enable vendors to supply appropriate tools for implementing integration of control systems to enterprise systems;
- c) enable users to better identify their needs;
- d) reduce the cost of automating manufacturing processes;
- e) optimize supply chains; and
- f) reduce life-cycle engineering efforts.

This standard may be used to reduce the effort associated with implementing new product offerings. The goal is to have enterprise systems and control systems that interoperate and easily integrate.

It is not the intent of the standards to

- a) suggest that there is only one way of implementing integration of control systems to enterprise systems;
- b) force users to abandon their current way of handling integration; or
- c) restrict development in the area of integration of control systems to enterprise systems.

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 2: Object model attributes

1 Scope

This part of ISA95, in conjunction with ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod), Enterprise-Control System Integration – Part 1: Models and Terminology, specifies generic interface content between manufacturing control functions and other enterprise functions. The interface considered is between Level 3 manufacturing systems and Level 4 business systems in the hierarchical model defined in Part 1. The goal is to reduce the risk, cost, and errors associated with implementing the interface.

Since this standard covers many domains, and there are many different standards in those domains, the semantics of this standard are described at a level intended to enable the other standards to be mapped to these semantics. To this end this standard defines a set of elements contained in the generic interface, together with a mechanism for extending those elements for implementations.

The scope of Part 2 is limited to the definition of object models and attributes of the exchanged information defined in Part 1.

This Part 2 standard does not define attributes to represent the object relationships.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod), Enterprise-Control System Integration – Part 1: Models and Terminology

ISA-88.00.01-1995, Batch Control – Part 1: Models and Terminology

IEC 62264-1, Enterprise-Control System Integration – Part 1: Models and terminology

IEC 61512-1, Batch control – Part 1: Models and terminology

ISO 19439, Enterprise integration - Framework for enterprise modeling

ISO 19440, Enterprise integration - Constructs for enterprise modeling

ISO 15704, Industrial automation systems--Requirements for enterprise-reference architectures and methodologies

ISO/IEC 19501, Information technology—Open Distributed Processing - Unified Modeling Language (UML) Version 1.4.2

ISO 10303-1, Industrial automation systems and integration – Product data representation and exchange – Part 1: Overview and fundamental principles

ISO 14977, Information Technology – Syntactic metalanguage – Extended BNF

ISO 15000-5, Core Components Technical Specification

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purpose of this part the definitions given in Part 1 and the following apply.

3.1.1

equipment class

a grouping of role based equipment with similar characteristics

3.1.2

event

representation of a solicited or unsolicited fact indicating a state change in the enterprise

3.1.3

location

the scope of exchanged information as identified by an element of the equipment hierarchy

EXAMPLE There may be an agreement to only supply an “Area” name for exchanged information, because the site and enterprise are implicitly defined through the messaging system

3.1.4

material class

a grouping of materials with similar characteristics

3.1.5

material lot

uniquely identifiable amount of a material

NOTE It describes the actual or planned total quantity or amount of material available, its current state, and its specific property values.

3.1.6

material definition

definition of the properties for a substance

NOTE This includes material that may be identified as raw, intermediate, final material, or consumable

3.1.7

material subplot

uniquely identifiable subset of a material lot

NOTE This may be a single item.

3.1.8

personnel class

a grouping of persons with similar characteristics

3.1.9

product

the desired output or by-product of the processes of an enterprise

NOTE 1: A product may be an intermediate product or end product from a business perspective

NOTE 2: Also defined in ISO 10303 Part 1 as: a substance produced by a natural or artificial process

3.1.10

property

implementation specific characteristic of an entity

3.2 Abbreviations

For purposes of this standard the following abbreviations apply.

MOM Manufacturing Operations Management

UML Unified Modeling Language

4 Production operations models and generic operations models

4.1 Information models

Common objects used in information exchange that relate to personnel, equipment, physical assets, and material are defined in Clause 5.

The information described in Part 1 for production operations management are represented in the Production Schedule Model, the Production Performance Model, Product Definition Model, and the Production Capability models, as shown in Figure 1. These objects are defined in Annex A.

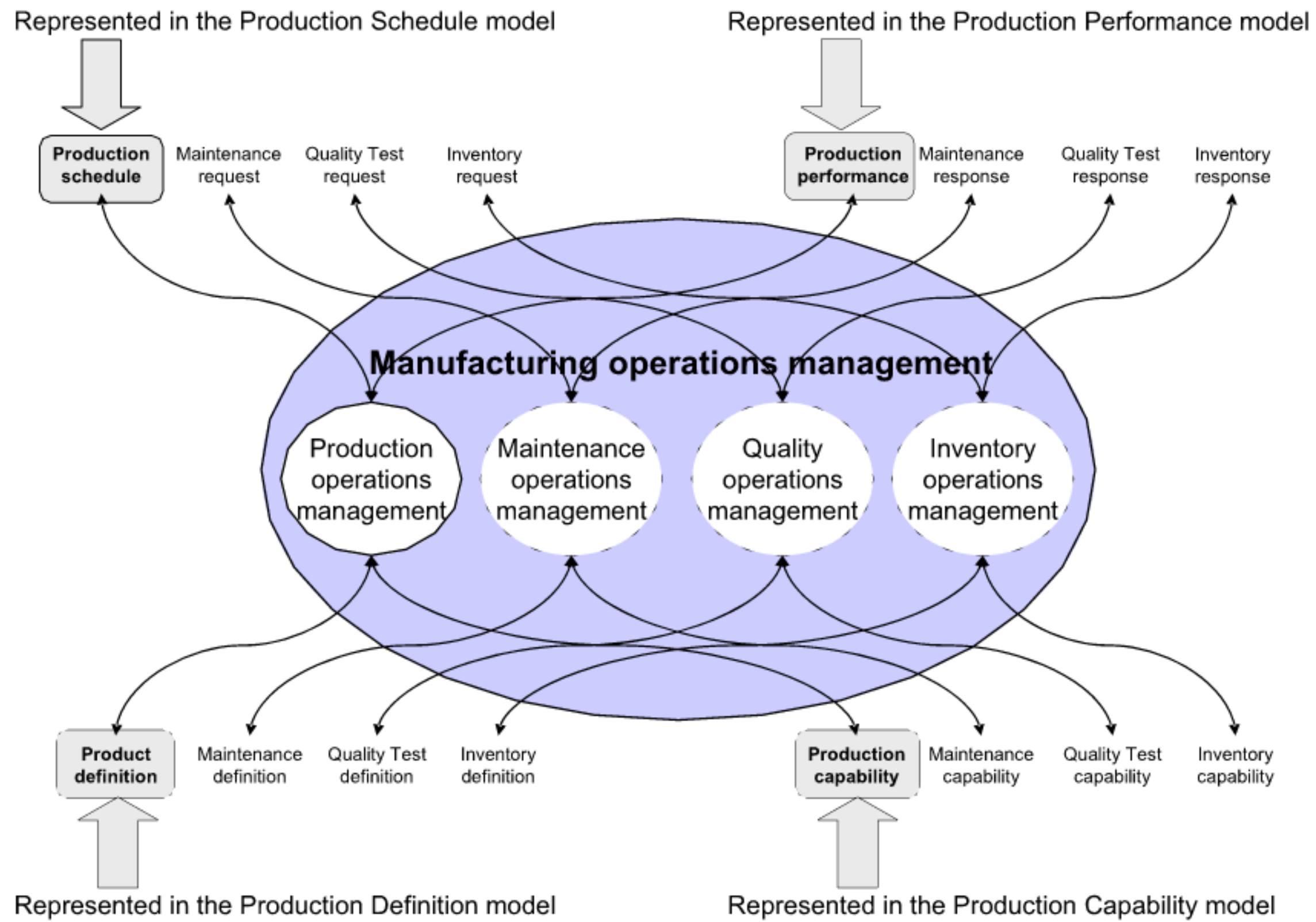


Figure 1 – Production operations management information models

A generic operations management information model is used to represent the information from other operations management areas which may be exchanged when more than production information is required. This is illustrated in Figure 2. These objects are defined in Clause 6.

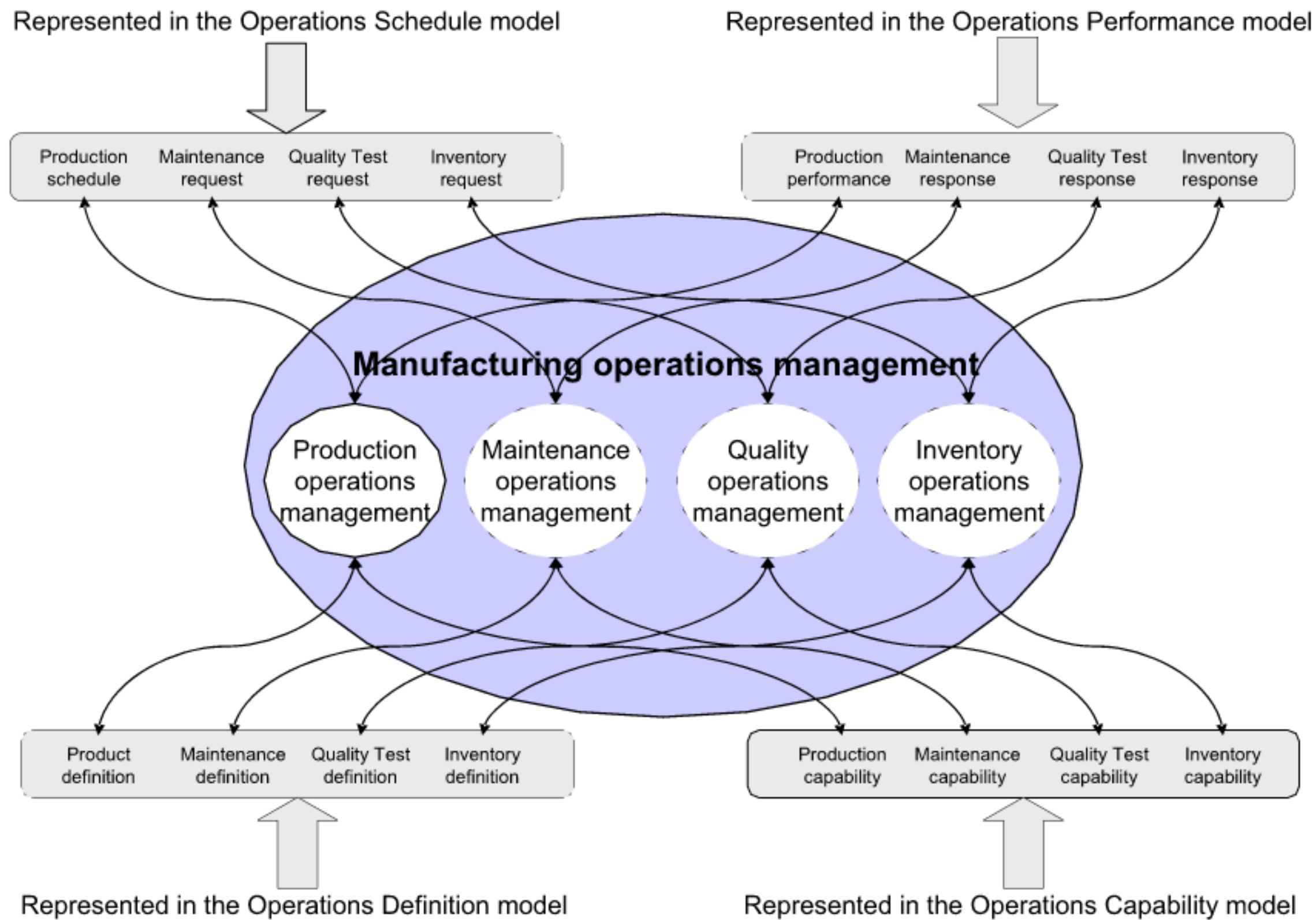


Figure 2 – Operations information models for operations management

4.2 General modeling information

This clause describes the object models and attributes for information exchanged in enterprise-control system integration. The attributes are part of the definition of terms.

In this standard, the word “Class” used as part of an object definition name is to be considered as a category, not as a “Class” in the UML Class sense.

EXAMPLE “Personnel Class” is to be considered a “Personnel Category”, in the sense of distinguishing between the kinds of personnel in the real world.

A minimum set of industry-independent information has been defined as attributes. However, values for all attributes may not be required depending on the actual usage of the models. If additional information, including industry- and application-specific information, is needed, it shall be represented as property objects. This mechanism is the extension capability referenced in the Scope section of this Part. This solution increases the usability through the use of standard attributes, and allows flexibility and extensibility through the use of properties. This was included to make the standard as widely applicable as practical.

4.3 Extensibility of attributes through properties

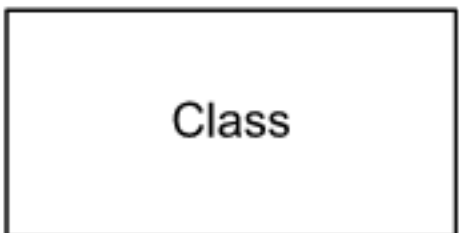
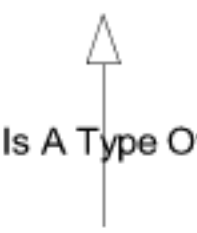
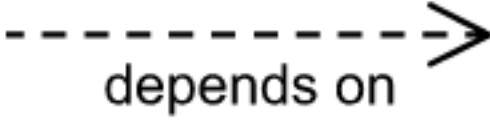
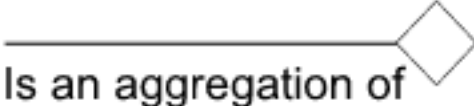
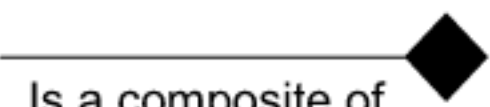
For particular applications the objects defined in the object models will need to be extended through the addition of attributes to object class definitions. Accordingly this Standard provides for attributes that are application or industry specific, to be modeled in terms of properties and represented in property classes in the model. For example, the personnel class property would be used to define application or industry specific attributes for personnel classes, and person property would be used to contain instance values for the properties.

4.4 Object model structure

The object models are depicted using the Unified Modeling Language (UML) notational methodology, as defined in ISO/IEC 19501.

Table 1 defines the UML notations used in the object diagrams.

Table 1 — UML notation used

Symbol	Definition
	Defines a package, a collection of object models, state models, use cases, and other UML models. Packages are general-purpose grouping mechanisms used to organize semantically related model elements. In this document a package is used to specify an external model, such as a production rule model, or a reference to another part of the model.
	Represents a UML class of objects, each with the same types of attributes. Each object is uniquely identifiable or enumerable. No operations or methods are listed for the classes.
	An association between elements of a class and elements of another or the same class. Each association is identified. May have the expected number or range of members of the subclass, when 'n' indicates an indeterminate number. For example, 0..n means that zero or more members of the subclass may exist.
	Generalization (arrow points to the super class) shows that an element of the class is a specialized type of the super class.
	Dependence is a weak association that shows that a modeling element depends on another modeling element. The item at the tail depends on the item at the head of the relationship.
	Aggregation (made up of) shows that an element of the class is made up of elements of other classes.
	Composite shows a strong form of aggregation, which requires that a part instance be included in at most one composite at a time and that the composite object has sole responsibility for disposition of its parts.

4.5 Explanation of tables

4.5.1 Tables of attributes

This subclause gives the meaning of the attribute tables. This includes a listing of the object identification, data types, and presentation of the examples in the tables.

All attributes in the tables shall be considered optional, except where specified as required in the attribute description.

4.5.2 Object identification

Many objects in the information model require unique identifications (IDs). These IDs shall be unique within the scope of the exchanged information. This may require translations:

- From the internal ID of the source system to the interface content ID
- From the interface content ID to the internal ID of the target system

EXAMPLE A unit may be identified as "X6777" in the interface content, as resource "R100011" in the business system, and as "East Side Reactor" in the control system.

A unique identification set shall be agreed to in order to exchange information.

The object IDs are used only to identify objects within related exchanged information sets. The object ID attributes are not global object IDs or database index attributes.

Generally, objects that are elements of aggregations, and are not referenced elsewhere in the model, do not require unique IDs.

4.5.3 Data types

The attributes presented are abstract representations, without any specific data type specified. A specific implementation will show how the information is represented.

EXAMPLE 1 An attribute may be represented as a string in one implementation and as a numeric value in another implementation.

EXAMPLE 2 A date/time value may be represented in ISO standard format in one implementation and in Julian calendar format in another. Attributes for date or time may contain values for a date, a date and time or a time value, the standard does not enforce the value semantics. Each implementation must negotiate the value semantics.

EXAMPLE 3 An object or attribute relationship may be represented by key fields in data base tables, or by parent/child elements in an XML by nested hierarchy.

4.5.4 Presentation of examples

Examples are included with each attribute given. Examples are presented for each of the main operations categories defined in Part 3 of this standard. See Table Table 2 below for how the example rows and columns are used.

Table 2 — Example table

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Name of first attribute	Description of first attribute	Production Example	Maintenance Example	Quality Example	Inventory Example
Name of second attribute	Description of second attribute	Production Example	Maintenance Example	Quality Example	Inventory Example
Name of third attribute	Description of third attribute	Production Example	Maintenance Example	Quality Example	Inventory Example

When an example value is a set of values, or a member of a set of values, the set of values is given within a set of braces, {}.

The examples are purely fictional. They are provided to further describe attributes in the model. No attempt was made to make the examples complete or representative of any manufacturing enterprise.

NOTE 1 — Within a table the columns for Production, Maintenance, Quality and Inventory may or may not be examples where the four operations management categories are coordinated or they may be separate examples. For example when one system is coordinating multiple operations management categories the IDs used in each column may be the same. When different systems coordinate multiple operations management categories the IDs may be different. Example attributes are meant to be illustrative, and do not imply requirements.

NOTE 2 — Time and date attributes may illustrate a general or specific time horizon. For example a yearly or quarterly plan may use general dates with no specific time, while a detailed schedule may include a specific time stamp down to the minute.

NOTE 3 — Data resolution for the examples will be fit for purpose, which means that each implementation will negotiate the appropriate resolution required for each attribute.

NOTE 4 — When (not applicable) is used as an example this is only illustrative that there is not a value for this attribute in this example. It does not imply there can never be a value. This is also true when all four columns contain (not applicable).

4.5.5 References to resources

The models used to document a reference to a resource, in another package, using the class or instance, with additional optional specification using properties, are not fully illustrated in the object model figures. This relationship is not conformant to the Unified Modeling Language (UML) modeling methodology, but was used to keep the diagrams simpler. Figure 3 below illustrates how it is currently presented, on the left side, and how it could be more accurately modeled in UML on the right side. UML was used in this standard as a visualization method and not meant to describe implementations. The simplified relationship diagram method is used for the following objects and their relationship to another package:

Personnel Capability	Equipment Capability
Material Capability	Personnel Segment Capability
Equipment Segment Capability	Material Segment Capability
Physical Asset Capability	Physical Asset Segment Capability
Personnel Segment Specification	Equipment Segment Specification
Material Segment Specification	Physical Asset Segment Specification
Personnel Specification	Equipment Specification
Material Specification	Physical Asset Specification
Personnel Requirement	Equipment Requirement
Material Requirement	Physical Asset Requirement
Personnel Actual	Equipment Actual
Material Actual	Physical Asset Actual

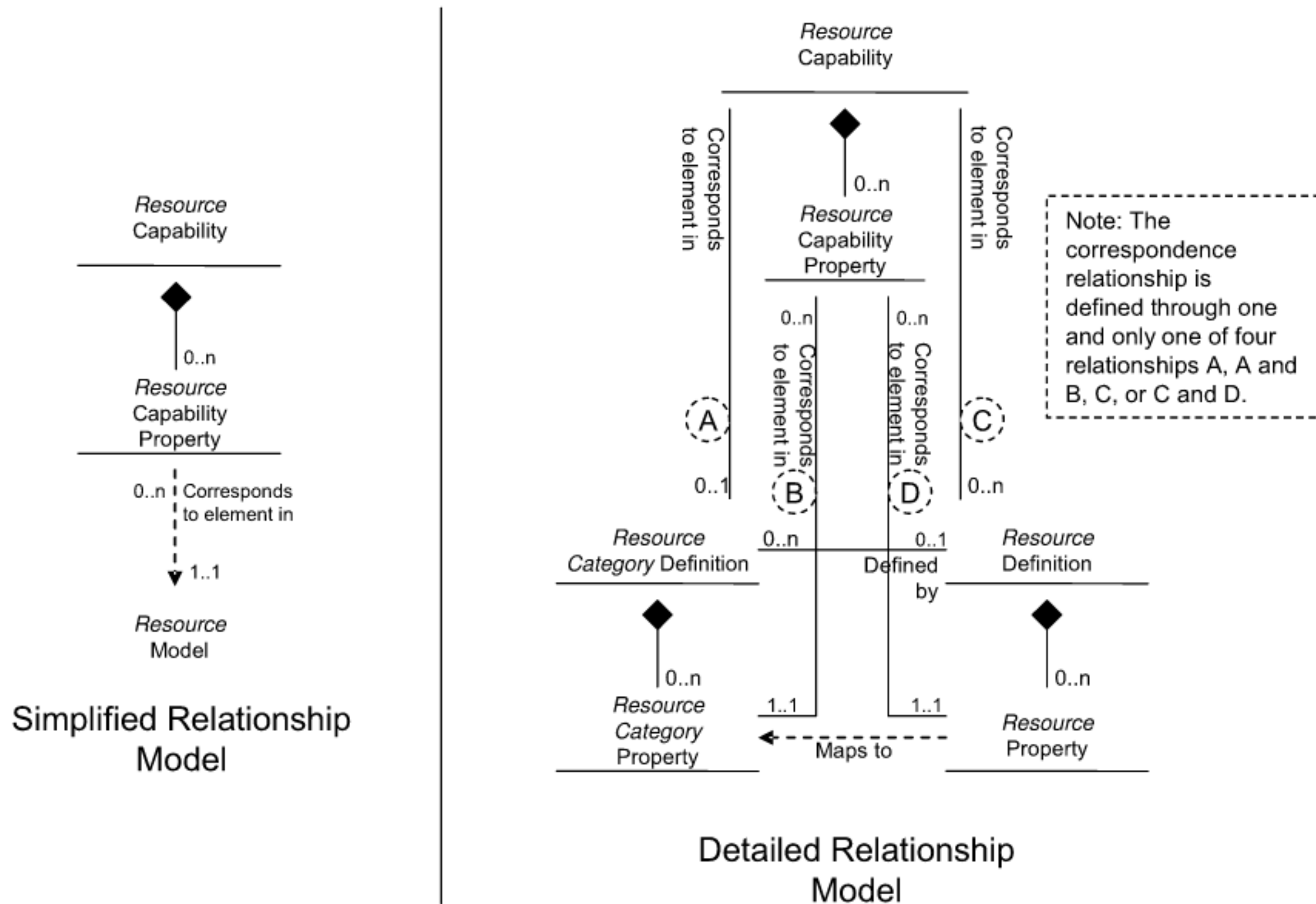


Figure 3 — Detailed resource relationship in models

The correspondence relationship is determined through one and only one of four possible relationships: to the *resource category definition*; to the *resource category definition* and *resource category property*; to the *resource definition*; or to the *resource definition* and *resource property*.

In the model above the term *resource category* indicates: personnel class, equipment class, physical asset class, material class, and material definitions. The term *resource* indicates: person, equipment, physical asset, material lot, and material subplot. The term *resource capability* indicates the use in the capability model, the process segment capability model, the process segment model, the product definition model, the production schedule model, and the production performance model.

4.5.6 Object relationships

This part does not define attributes to represent the object relationships.

NOTE Different implementations of the object models will have different methods for representing the object relationships. While the relationships may be represented as additional attributes on one implementation, such as a database, they could be represented as containment in another implementation, such as an XML document.

4.6 Relationship of models

The common information object models in Clause 5 describe the different types of resources and their uses in describing a (business) Process segment. These object models are also used to describe the other (manufacturing) operations management information object models in Clauses 6, 7 and 8.

The operations management information object models described in Clause 6 shall be used for any manufacturing operations category, such as, Production, Maintenance, Quality, Inventory, and Inventory Handling, as defined in Part 3. Although the generic object model can also be used to describe operations management information models for user-defined operations categories, conformance can be evaluated only if user-specific conformance testing scenarios are available.

Also additional explanations to assist in applying these object definitions to describe the interoperability among the following operations management categories are provided in Annex E:

- Production Operations;
- Maintenance Operations;
- Quality Operations;
- Inventory (Handling) Operations;
- Mixed Operations;
- User-defined Operations.

The Production Information Models described in Annex A reproduce the models in earlier versions of this standard in order to ensure the conformance of existing implementations of the standard:

- An Operations Definition for Production Operations is the equivalent of a Product Definition
- An Operations Schedule for Production Operations is the equivalent of a Production Schedule.
- An Operations Performance for Production Operations is the equivalent of a Production Performance.
- An Operations Capability for Production Operations is the equivalent of a Production Capability

However, for future implementations, it is recommended to use the Operation models in Clause 6.

4.7 Hierarchy scope

Hierarchy scope is an attribute used in many other objects. The hierarchy scope attribute identifies where the exchanged information fits within the role based equipment hierarchy. It defines the scope of the exchanged information, such as a site or area for which the information is relevant. The hierarchy scope identifies the associated instance in the role based equipment hierarchy.

NOTE The hierarchy scope attribute is optional and may not be needed if the context of the exchanged information can be determined based on the exchange mechanism used.

EXAMPLE 1 A hierarchy scope may identify a SITE, such as WEST-END. A *Production Performance* may have a *Hierarchy Scope* attribute that identifies the WEST-END site.

EXAMPLE 2 A hierarchy scope may identify an AREA within a SITE, such as WEST-END/HOLDING-AREA. A *Production Capability* may have a *Hierarchy Scope* attribute that identifies the area.

EXAMPLE 3 A hierarchy scope may identify a WORK CENTER within an AREA or SITE, such as WEST-END/HOLDING-AREA/CHIPPING-BIN #1.

EXAMPLE 4 A hierarchy scope may identify a WORK CENTER without an AREA or SITE identification because these are already known due to the exchange mechanism, such as CHIPPING-BIN #1.

EXAMPLE 5 A hierarchy scope may identify a complete hierarchy of ENTERPRISE, SITE, AREA, WORK CENTER.

The hierarchy scope attribute may be modeled using the model illustrated in Figure 4 with attributes for the Hierarchy Scope object defined in Table 3. Each Hierarchy Scope object defines one element in the equipment hierarchy,

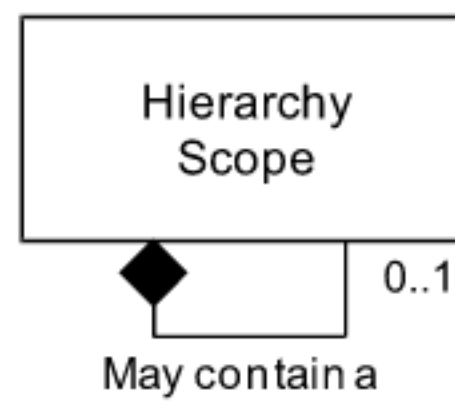


Figure 4 — Hierarchy scope model

Table 3 — Attributes of hierarchy scope

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Equipment ID	A unique identification of an equipment element	WorkCenter23	West End	Ajax	North Size
Equipment Element Level	Identification of the equipment level if the equipment element	Work Center	Site	Enterprise	Area

4.8 Value types

4.8.1 Value use

Value attributes are used in properties, parameters, and data to exchange actual values.

Value attributes are also used to exchange the allowed or expected values in properties and parameters for Material Definitions, Material Classes, Equipment Classes, Personnel Classes, Physical Asset Classes, Process Segments, Operations Definitions, and Product Definitions. Value types thus represent actual single values, actual arrays of values, and ranges of possible values, either as numerical or textual ranges or as sets of values.

4.8.2 Value syntax

The format for values in value attributes is not defined in this part and will be defined by implementations of the standard.

The following syntax, defined in an EBNF notation from ISO 14977, may be used to represent single element values, range specifications, arrays of values, and a set of allowed values as delimited text strings.

```

<value> ::= <simpleValue>
          | <arrayValue>
          | <rangeValue>
          | <seriesValue>

<arrayValue> ::= “[ <arrayElement> *( “,” <arrayElement> ) ”]”
<rangeValue> ::= “{ <rangeElement> *( “,” <rangeElement> }”
<seriesValue> ::= “< <simpleValue> *( “,” <simpleValue> ) >”
<arrayElement> ::= <simpleValue> | <arrayValue>
<rangeElement> ::= <simpleValue> “..” <simpleValue>
<simpleValue> ::= string

```

4.8.3 Simple value types

Simple value types may be derived from core component types that are compatible with the ISO-15000-5 Core Component Technical Specification (CCTS). The CCTS types are a common set of types that define specific terms with semantic meaning (e.g. the meaning of a quantity, currency, amount, and identifier).

Commonly used CCTS types for exchange are:

AmountType	Used to define a number of monetary units specified in a currency where the unit of currency is explicit or implied.
BinaryObjectType	Used to define a data types representing graphics, pictures, sound, video, or other forms of data that can be represented as a finite length sequence of binary octets.
CodeType	Used to define a character string that is used to represent a entry from a fixed set of enumerations.
DateTimeType	Used to define a particular point in time together with the relevant supplementary information to identify the timezone information. This is a specific instance on time using the ISO 8601 CE (Common Era) calendar extended format and abbreviated versions.
IdentifierType	Used to define a character string to identify and distinguish uniquely, one instance of an object in an identification scheme from all other objects in the same scheme.
IndicatorType	Used to define a list of two mutually exclusive Boolean values that express the only possible states of a Property. For example “ True ” or “ False ”.
MeasureType	Used to define a numeric value determined by measuring an object along with the specified unit of measure.

NumericType	Numeric information that is assigned or is determined by calculation, counting, or sequencing. It does not require a unit of quantity or unit of measure.
QuantityType	Used to define a counted number of non-monetary units, possibly including fractions.
TextType	Used to define a character string (i.e. a finite set of characters) generally in the form of words of a language.

4.8.4 Unit of measure

This standard defines attributes for value, quantity, and other units of measure. The unit of measure was explicitly specified to ensure that it was not missed in information exchanges. Implementations of this standard may represent the unit of measure in the manner appropriate for the implementation.

4.8.5 Array value types

Arrays of values may be represented following the syntax defined in the EBNF above.

EXAMPLE 1: A set of values for a single dimension array with 6 values would be represented as:

[1 , 2 , 3 , 4 , 5 , 6]

EXAMPLE 2: A set of values for a two dimension array of size 2x3 would be represented as:

[[1 , 2] , [3 , 4] , [5 , 6]]

4.8.6 Range value types

Range specifications may be represented following the syntax defined in the EBNF above.

EXAMPLE 1: A simple range of values may be represented as:

{ 0 .. 100 }

EXAMPLE 2: A non-continuous range of values may be represented as:

{ a .. z , A .. Z }

{ 0 .. 100 , 200 .. 300 , 500 , 600 .. 650 }

4.8.7 Series value types

A specification defined as a set of allowed values may be represented following the syntax defined in the EBNF above.

EXAMPLE 1: A series of values that define colors may be represented as:

< Red , Green , Yellow , Blue >

EXAMPLE 2: A series of values that define equipment hierarchy levels may be represented as:

<Enterprise , Site , Area , WorkCenter , WorkUnit>

4.8.8 Structured value types

Structured data elements may be represented in this standard’s property model by representing the atomic elements of the structure in a flattened name space, or by using nested properties to represent the data structure.

NOTE 1: The decision to use a flattened name space, nested properties, or a combination is determined by the specific implementation.

A structure may be modeled by flattening the name space and having a single property for each structure element.

NOTE 2: This standard specifies how to exchange information without regard to the specific exchange element’s mapping. With structured elements there is no guarantee that the communicating entities would have the same structure for the data. Therefore flattening the structure to its individual elements provides a transportable format for structured data.

EXAMPLE 1: A structured element of data would be mapped to a flat name space as follows:

Structure Definition	Flattened Property Name
Struct ABC {	
Integer DEF ;	ABC.DEF
Float GHI;	ABC.GHI
Array [3] of Integer JKI	ABC.JKI
}	

A structured data element may be represented by creating a property with no data value or unit of measure and with nested child properties and an identification of the element.

EXAMPLE 2: A structured data element may be mapped as follows:

C# Structure Definition	Equivalent Property
struct Simple {	Property [ID="Simple"]
public int Position;	Property [ID="Simple"] \ Property [ID="Position"]
public bool Exists;	Property [ID="Simple"] \ Property [ID="Exists"]
public double LastValue;	Property [ID="Simple"] \ Property [ID="LastValue"]
};	

A grouping or collection of related properties may be represented by creating a property with nested child properties.

EXAMPLE 3: A collection of related nominal properties may be mapped as follows:

Collection of Properties	Property Structure
	Property [ID="Nominal"]
NominalRate	Property [ID="Nominal"] \ Property [ID="NominalRate"]
ExpectedRate	Property [ID="Nominal"] \ Property [ID="ExpectedRate"]
LabelCode	Property [ID="Nominal"] \ Property [ID="LabelCode"]

Nested property objects are only shown in the Personnel, Equipment, Physical Asset, and Material models. All property objects are also nested, as defined in the appropriate section in the text, but are not shown in the model figures in order to reduce the complexity of the figures.

5 Common object models

5.1 Personnel information

5.1.1 Personnel model

The personnel model shown in Figure 5 contains the information about specific personnel, classes of personnel, and qualifications of personnel.

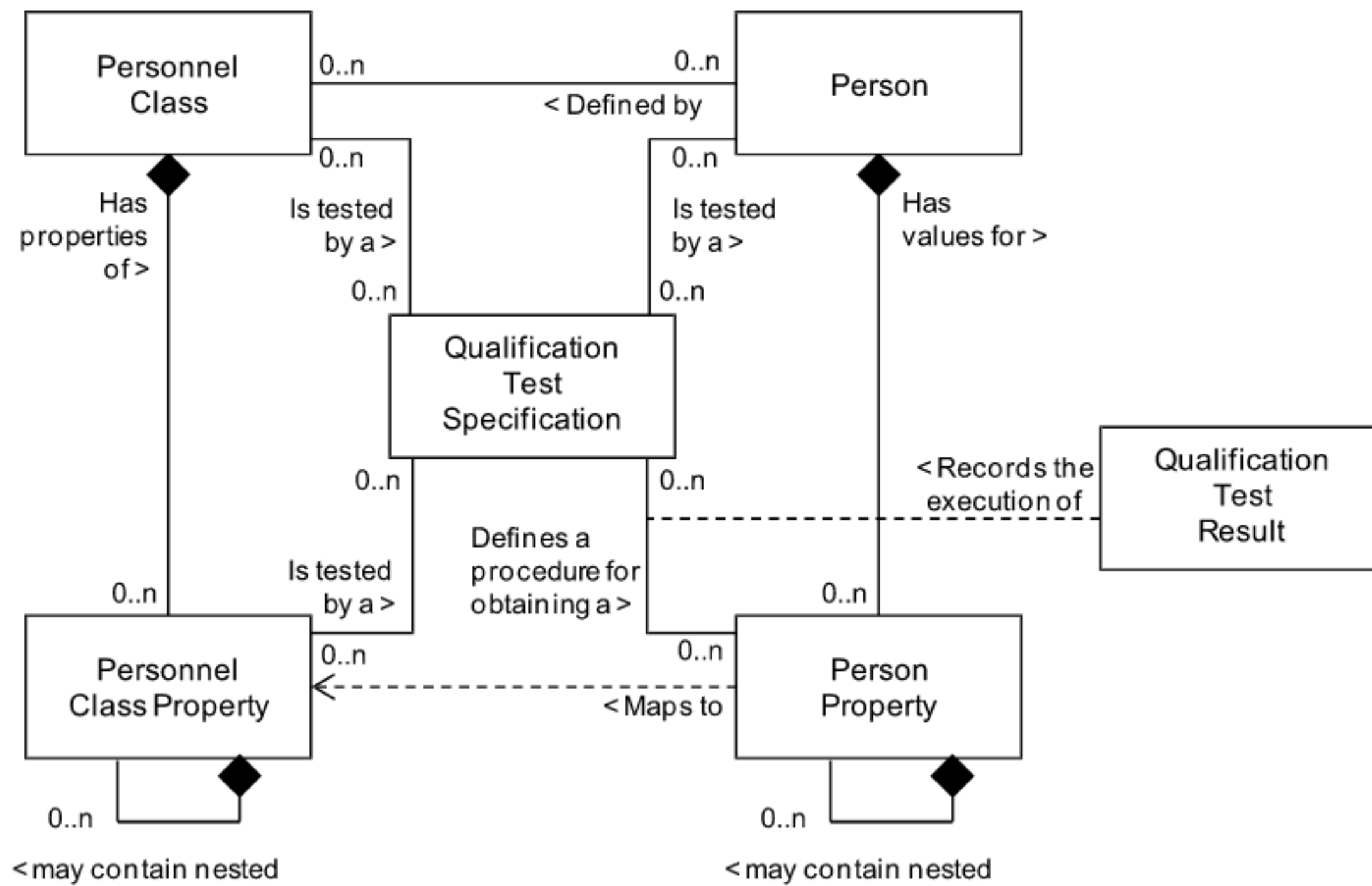


Figure 5 — Personnel model

5.1.2 Personnel class

A personnel class is a representation of a grouping of persons with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance. Any person may be a member of zero or more personnel classes. Table 4 lists the attributes of *personnel class*. A personnel class may be tested by the execution of a qualification test specification.

NOTE Examples of personnel classes are cook machine mechanics, slicing machine operators, cat-cracker operator, and zipper line inspectors.

Table 4 — Attributes of personnel class

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific <i>personnel class</i> . These are not necessarily job titles, but identify classes that are referenced in other parts of the model.	Widget Assembly Operator	Maintenance Technician Grade 1	Senior Lab Assistant	Warehouse Manager
Description	Additional information and description about the <i>personnel class</i> .	General information about widget assembly operators.	Highest grade for maintenance technician	Highest level of lab assistants	Person responsible for the warehouse

EXAMPLE A personnel class may be associated to a qualification test specification without reference to a property, such as a qualification test specification for a fork truck operator, in which the test determined if the person is a member of the class of fork truck operators.

5.1.3 Personnel class property

Properties of a personnel class shall be shown as personnel class properties. Each personnel class shall have zero or more recognized properties. Table 5 lists the attributes of *personnel class property*.

NOTE Examples of personnel class properties for the personnel class operators are class 1 certified, class 2 certified, night shift, and exposure hours.

Production requests may specify required personnel class property requirements for a product segment.

A personnel class property may be tested by the execution of a qualification test specification.

Personnel class properties may contain nested personnel class properties.

Table 5 — Attributes of personnel class property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific property, unique under the scope of the parent <i>personnel class</i> object. For example, the property “ <i>Has Class 1 Safety Training</i> ” (with values of <i>Yes</i> or <i>No</i>) may be defined under several different <i>Personnel Class</i> definitions, such as <i>Fork Lift Operator</i> and <i>Pipe Fitter</i> classes, but has a different meaning for each class.	Class 1 Certified	Electrician Skills Class	LGC Model 1003 Certified Operator	Lift Truck Driver
Description	Additional information and description about the <i>personnel class property</i> .	Indicates the certification level of the operator.	Level of Skill Attained	Indicates if qualified to run equipment	Indicates if allowed to drive lift trucks
Value	The value, set of values, or range of the property. This presents a range of possible numeric values, a list of possible values, or it may be empty if any value is valid.	<True, False>	<Master, Journeyman, Apprentice>	<True, False>	<True, False>
Value Unit of Measure	The unit of measure of the associated property values, if applicable.	Boolean	String	Boolean	Boolean

5.1.4 Person

A person is a representation of a specifically identified individual. A person may be a member of zero or more personnel classes. Table 6 lists the attributes of *person*. A person may be tested by the execution of a qualification test specification.

Person shall include a unique identification of the individual.

Table 6 — Attributes of person

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific person, within the scope of the information exchanged (<i>production capability, production schedule, production performance, ...</i>) The ID shall be used in other parts of the model when the <i>person</i> needs to be identified, such as the <i>production capability</i> for this person, or a <i>production response</i> identifying the person.	Employee 23	22828	999-123-4567	007
Description	Additional information about the resource.	Person Information	Maintenance Tech	Lab Tech	Driver
Name	The name of the individual. This is meant as an additional identification of the resource, but only as information and not as a unique value.	Jane	Jim	John	James

5.1.5 Person property

Properties of a person shall be listed as person properties. Each person shall have zero or more person properties. These specify the current property values of the person for the associated personnel class property. Table 7 lists the attributes of *person property*.

NOTE For example, a person property may be night shift and its value would be available, and a person property may be exposure hours available and its value would be 4.

Person properties may include the current availability of a person and other current information, such as location and assigned activity, and the unit of measure of the current information.

A person property may be tested by the execution of a qualification test specification with test results exchanged in a qualification test result.

Person properties may contain nested person properties.

Table 7 — Attributes of person property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific property.	Exposure Hours Available	Union ID	LGC Model 1003 Certified Operator	Lift Truck Driver
Description	Additional information about the <i>person property</i> .	Indicates number of exposure hours available this month	Union ID number	Indicates if qualified to run equipment	Indicates if allowed to drive lift trucks
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related <i>personnel class property</i> .	4	CA55363	True	False
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Hours	String	Boolean	Boolean

5.1.6 Qualification test specification

A representation of a qualification test shall be presented as a qualification test specification. A qualification test specification may be associated with a personnel class, a personnel class property, a person, or person property. This is typically used where a qualification test or properly demonstrated competency is required to ensure that a person has the correct training and/or experience for specific operations. A qualification test specification may test for one or more properties. Table 8 lists the attributes of *qualification test specification*.

A qualification test specification shall include

- a) an identification of the test;
- b) a version of the test;
- c) a description of the test.

Table 8 — Attributes of qualification test specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a test for certifying one or more values for one or more <i>person properties</i> . For example, this may be the name of a document that describes or defines the qualification test.	Class 1 Widget Assembly Certification Test	Union Renewal Test	LGC Model 1003 Certification Test	Fork Truck Driving Test
Description	Additional information and description about the <i>qualification test specification</i> .	Identifies the test for Class 1 Widget assembly certification – returns a True or False value for the <i>Class 1 widget assembly certification</i> property	Renewal for union membership	Identifies test for correct operation of LGC Model 1003	Identifies test for driving fork truck
Version	An identification of the version of the qualification test specification.	V23	01	A	23C

5.1.7 Qualification test result

The results from a qualification test for a specific person shall be given as a qualification test result. Table 9 lists the attributes of *qualification test result*.

A qualification test result shall include

- the date of the test;
- the result of the test (for example, passed or failed);
- the expiration date of the qualification.

Table 9 — Attributes of qualification test result

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique instance identification that records the results from the execution of a test identified in a <i>qualification test specification</i> for a specific <i>person</i> . (For example, this may just be a number assigned by the testing authority.)	T5568700827	UR20070809	LGC553	77276
Description	Additional information and description about the <i>qualification test results</i> .	Results from Joe's widget assembly qualification test for October 1999.	Renewal	Particle Analyzer SOP Test	Fork lift driver safety SOP test
Date	The date and time of the qualification test.	1999-10-25 13:30	2007-08-09	2006-10-31 08:40	2002-01-30
Result	The result of the qualification test. For example: Pass, Fail	Pass	Pass	Fail	Fail
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	<Pass, Fail>	<Pass, Fail>	<Pass, Fail>	<Pass, Fail>
Expiration	The date of the expiration of the qualification.	2000-10-25 13:30	2008-08-09	2008-10-31	(not applicable)

5.2 Role based equipment information

5.2.1 Role based equipment model

The role based equipment model shown in Figure 6 contains the information about specific equipment, the classes of equipment, and equipment capability tests.

The formal UML role based equipment model object is used to define the role based equipment hierarchy information that is defined in Part 1 of this standard. The model contains the information that may be used to construct the hierarchical models used in manufacturing scenarios. For purposes of corresponding to the Part 1 models, the defined equipment levels, specified in the Equipment Level attributes, for role based equipment are: Enterprise, Site, Area, Work Center, Work Unit, Process Cell, Unit, Production Line, Production Unit, Work Cell, Storage Zone, and Storage Unit.

NOTE 1 The types of work centers may be extended when required for application specific role based equipment hierarchies where the defined types do not apply. When a new type is added it shall maintain the same relationship within the hierarchy as the defined work center types (within an area and contains work units).

EXAMPLE 1 Laboratory may be an extended equipment level that defines a Work Center that includes all equipment in a test lab.

EXAMPLE 2 A Maintenance Storage Center may be an extended equipment level that defines a Work Center that includes all equipment used by maintenance activities.

EXAMPLE 3 A Mobile Equipment Center may be a work center that includes all mobile equipment which may be used at different work centers or areas at different points in time.

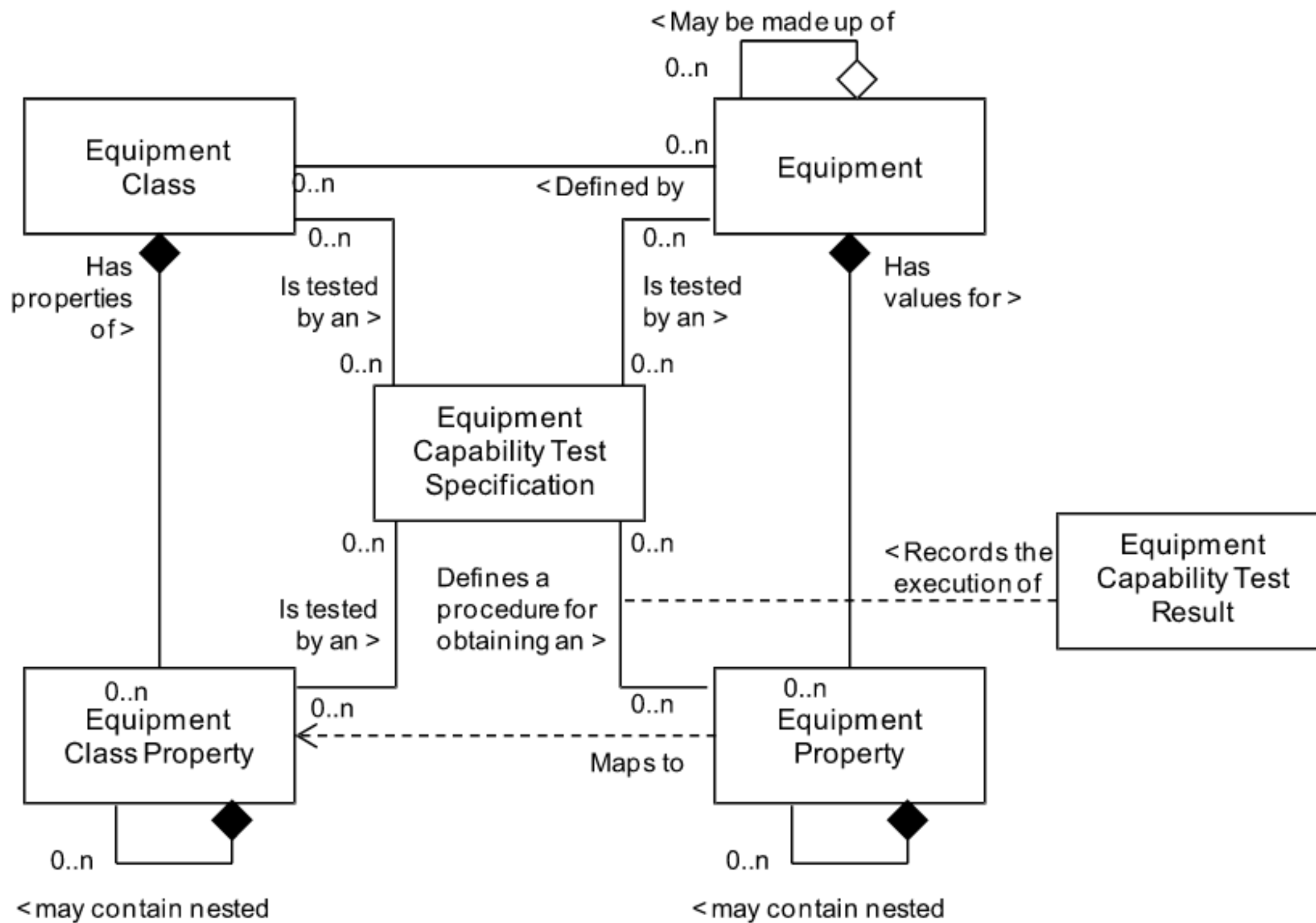


Figure 6 — Role based equipment model

5.2.2 Equipment class

An equipment class is a representation of a grouping of equipment with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance. Any piece of equipment may be a member of zero or more equipment classes. Table 10 lists the attributes of *equipment class*. An equipment class may be tested by the execution of an equipment capability test specification.

NOTE Examples of equipment classes are reactor unit, bottling line, and horizontal drill press.

Table 10 — Attributes of equipment class

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific <i>equipment class</i> , within the scope of the information exchanged (<i>production capability</i> , <i>production schedule</i> , <i>production performance</i> , ...) The ID shall be used in other parts of the model when the <i>equipment class</i> needs to be identified, such as the <i>production capability</i> for this equipment class, or a <i>production response</i> identifying the equipment class used.	WJ6672892	Welder	5662AT	DR-FLT
Description	Additional information about the <i>equipment class</i> .	Jigs used to assemble widgets.	Welder to be signed out	Auto Titration Tester	Deep Reach Fork Truck
Equipment Level	An identification of the level in the role based equipment hierarchy.	Production Line	Work Center	Site	Area

5.2.3 Equipment class property

Properties of an equipment class shall be listed as equipment class properties. Each may have zero or more recognized properties. Table 11 lists the attributes of *equipment class property*. An equipment class property may be tested by the execution of an equipment capability test specification.

Equipment class properties may contain nested equipment class properties.

NOTE Examples of equipment class properties for the equipment class reactor unit may be lining material, BTU extraction rate, and volume.

Table 11 — Attributes of equipment class property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific property.	Template Size	Capacity	Resolution	Max Weight
Description	Additional information about the <i>equipment class property</i> .	Range of template sizes for widget machines.	Capacity of the welder	Minimum peak resolution	Maximum carrying weight for the truck
Value	The value, set of values, or range of the property.	{10,20,30,40, 100,200,300}	{10..400}	{1 ..10}	{2000 .. 36000}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	cm	Amperes	ppm	Kg

5.2.4 Equipment

A representation of the elements of the equipment hierarchy model shown in Part 1 shall be known as equipment. Equipment may be a listing of sites, areas, production units, production lines, work cells, process cells, units, storage zones or storage units. Table 12 lists the attributes of *equipment*. Equipment may be tested by the execution of an equipment capability test specification.

Equipment may be made up of other equipment, as presented in the equipment hierarchy model.

EXAMPLE 1 A production line may be made up of work cells.

EXAMPLE 2 A reactor may be made up of sensors, valves, an agitator, and level switches.

Table 12 — Attributes of equipment

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific piece of equipment, within the scope of the information exchanged (manufacturing operations definition, scheduling, capability and performance) The equipment ID shall be used in other parts of the model when the equipment needs to be identified, such as the <i>production capability</i> for a piece of equipment, or a <i>production response</i> identifying the equipment used.	Jig 347	Wldr445	SN3883AT	VIN28203
Description	Additional information about the equipment.	This is the east side, north building, widget jig.	Welder for north building	Floor 2 lab auto titrator	Shipping dock lift truck
Equipment Level	An identification of the level in the role based equipment hierarchy.	Production Line	Work Center	Site	Area

5.2.5 Equipment property

Properties of equipment shall be listed as equipment properties. An equipment shall have zero or more equipment properties. These specify the current property values of the equipment for the associated equipment class property. Equipment properties may include a unit of measure. Table 13 lists the attributes of *equipment property*. An equipment property may be tested by the execution of an equipment capability test specification with results exchanged in an equipment capability test result.

Equipment properties may contain nested equipment properties.

NOTE: An equipment property may exist without an associated equipment class property, however all parties in an exchange must have a common understanding of the equipment property.

EXAMPLE 1 An equipment class property may be volume with a value of {10000 – 50000} with a unit of measure of liters, an equipment property may be volume with a value of 30.000 and a unit of measure of liters.

EXAMPLE 2 Examples of equipment properties are

- other current information, such as when calibration is needed;
- maintenance status;
- the current state of the equipment;
- performance values.

Table 13 — Attributes of equipment property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific property.	Run Rate	Capacity	Resolution	Max Weight
Description	Additional information about the <i>equipment property</i> .	Widget making average run rate	Capacity of the welder	Minimum peak resolution	Maximum carrying weight for the truck
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related <i>equipment property</i> .	59	{10-200}	0.05	1
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Widgets/Hour	Amperes	%	Tons

5.2.6 Equipment capability test specification

A representation of a capability test shall be presented as an equipment capability test specification. An equipment capability test specification may be associated with an equipment class, equipment class property, equipment or equipment property. This is typically used where a test is required to ensure that the equipment has the necessary capability and capacity. An equipment capability test specification may test for one or more equipment properties. Table 14 lists the attributes of *equipment capability test specification*.

An equipment capability test specification shall include

- a) an identification of the test;
- b) a version of the test;
- c) a description of the test.

Table 14 — Attributes of equipment capability test specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a test for certifying one or more values for one or more <i>equipment properties</i> . For example, this may be the name of a document that describes or defines the capability test.	WAJTT-101	Wldr_check	ATT-Calibrate	FLT_Safety
Description	Additional information about the <i>equipment capability test specification</i> .	Widget assembly jig throughput test – returns the run rate for a specific machine	Welder Safety Check	Auto Titration tester Calibration	Lift truck safety truck
Version	An identification of the version of the capability test specification.	1.0	2.3	1.1	1.1

5.2.7 Equipment capability test result

The results from an equipment capability test for a specific piece of equipment shall be shown as an equipment capability test result. Table 15 lists the attributes of *equipment capability test result*.

An equipment capability test result shall include

- a) the date of the test;
- b) the result of the test (passed-failed or quantitative result);
- c) the expiration date of the test.

Table 15 — Attributes of equipment capability test result

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique instance identification that records the results from the execution of a test identified in a <i>capability test specification</i> for a specific piece of <i>equipment</i> . (For example, this may just be a number assigned by the testing authority.)	FQ101/01-10-2000	WC888	AT98765	FS7602
Description	Additional information about the <i>equipment capability test result</i> .	Results from run rate test for JIG 237 for October 1999.	Results from safety check	Results from calibrate	Results from safety check
Date	The date and time of the capability test.	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30
Result	The result of the capability test.	48	Fail	Pass	Pass
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	Widgets/Hour	<Pass, Fail>	<Pass, Fail>	<Pass, Fail>
Expiration	The date of the expiration of the capability.	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30

5.2.8 Containers

A container for material shall be represented as role based equipment, physical asset, or both of type storage zone or storage unit.

EXAMPLE 1 In a refinery; bulk storage tanks would be represented as Storage Units and as containers for specific materials.

EXAMPLE 2 In an automotive plant; assembly parts bins would be represented as Storage Units and as containers for an assembly of parts.

EXAMPLE 3 In a pharmaceutical plant; portable tote bins or pallets that hold tablets would be represented as Storage Units for a specific material lot or subplot.

EXAMPLE 4 Properties of containers would be represented as Equipment Class, Equipment, Physical Asset Class, or Physical Asset properties, such as: Readiness, Transportability, Disposable, and Cleanness.

The association of material lots and sublots to containers is modeled as properties of the material lot or subplot.

The association of containers to material lots and sublots is modeled as properties of the container.

5.2.9 Tools

A tool shall be represented as role based equipment, physical asset, or both.

EXAMPLE 1 In a pharmaceutical plant; a tablet die used to compress and shape tablets would be represented as a Work Unit. The tablet die work unit may have properties that identified the expected use time and the actual use time.

EXAMPLE 2 In plastics parts manufacturing; an extruder die would be represented as a Work Unit. The extruder machine could be represented as a Work Cell.

EXAMPLE 3 In semiconductor manufacturing; a multi-platen multi-wafer CMP (Chemical Mechanical Polishing) tool would be represented as a Work Cell.

EXAMPLE 4 A micrometer used for measuring sheet metal thickness in a general purpose machine shop may be recorded as equipment but not tracked as a physical asset.

5.2.10 Software

Software shall be represented as role based equipment, physical asset, or both.

NOTE Level 3 applications may have responsibility for keeping the actual software up to date. In the context of this standard, information about the software may need to be specified, required, reported or synchronized with Level 4 systems.

EXAMPLE 1 When a patch is applied to software the change may need to be known by Level 3 systems to allow additional testing and Level 4 systems to update security settings.

EXAMPLE 2 When a physical asset is decommissioned and it contains licensed software, then a Level 4 system may need the information to order software uninstalls, to order asset memory clearing or to know to cancel the maintenance license fee.

5.3 Physical asset information

5.3.1 Physical asset model

The physical asset model contains information about the physical piece of equipment, usually managed as a physical asset within the enterprise often utilizing a specific serial number. An object in the equipment model defines a role for the equipment, and object in the asset model defines the physical ID and properties of a piece of equipment.

EXAMPLE Equipment IDs can be represented as TAGs, which define a role such as TC184 for a temperature controller, while the temperature controller is an asset and has a serial number (TC_WED_9982002922).

The physical asset can be replaced (e.g. because it is broken) and in that case the TAG will not change, but a new physical asset with a unique serial number will take the place of the old physical asset. Therefore two separate ID's are needed, one for the role (equipment ID) and one for the physical asset (physical asset ID).

While assets have Level 4 significance, usually because they have an economic value, this part of the standard focuses on the Level 3 significance of the asset. The asset model defines a physical asset as a representation of a physical piece of equipment.

Definitions for hierarchy levels in the physical asset hierarchy are not defined in this Part, however the role-based equipment hierarchy names should be used if they are equivalent.

A representation of physical asset equipment is illustrated in Figure 7.

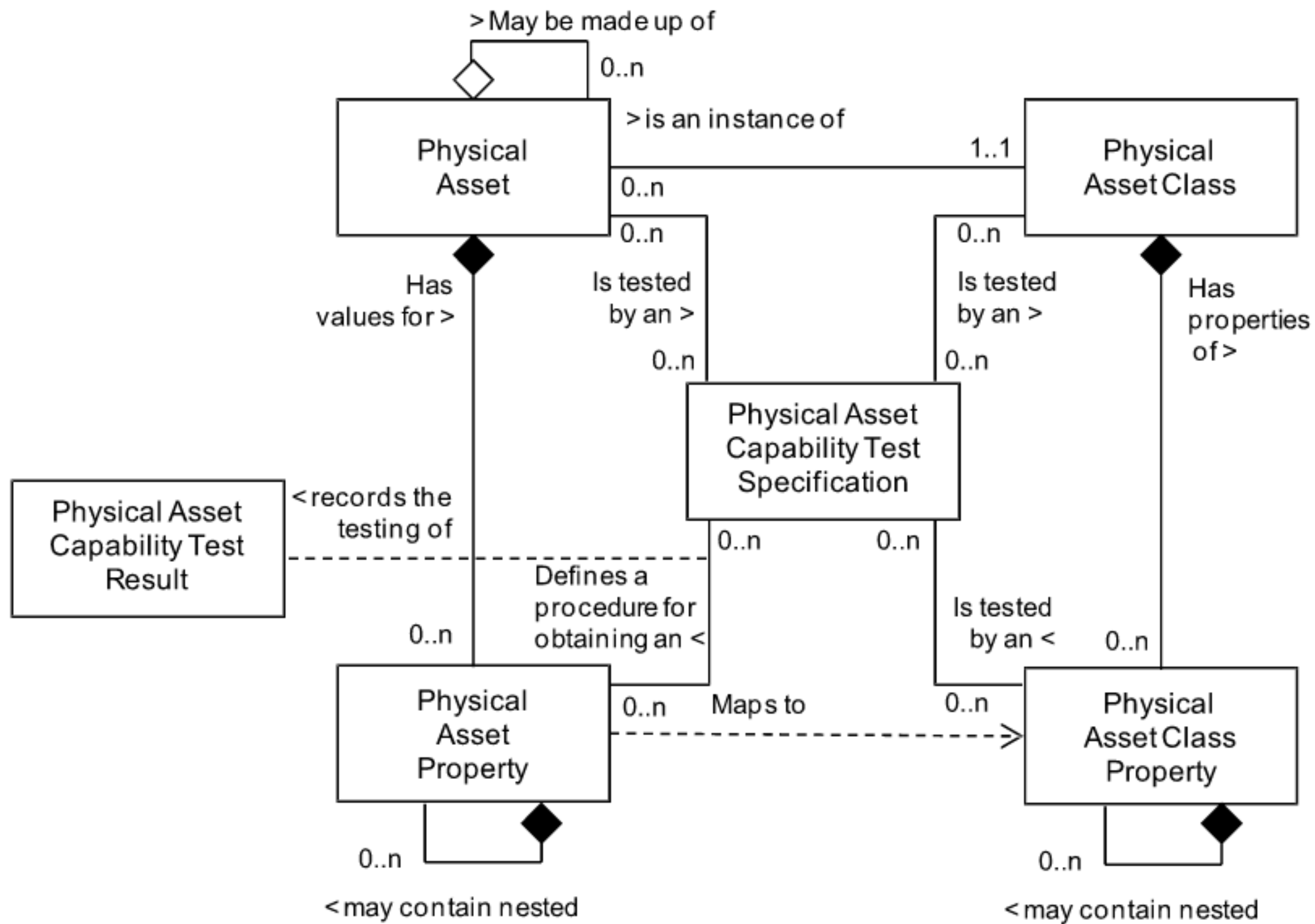


Figure 7 — Physical asset model

The relationship between the physical asset information and the equipment information is shown in Figure 8. There is a temporal relationship between the role of the equipment and the physical asset. The physical asset performing the role may change over time and the equipment asset mapping maintains the association.

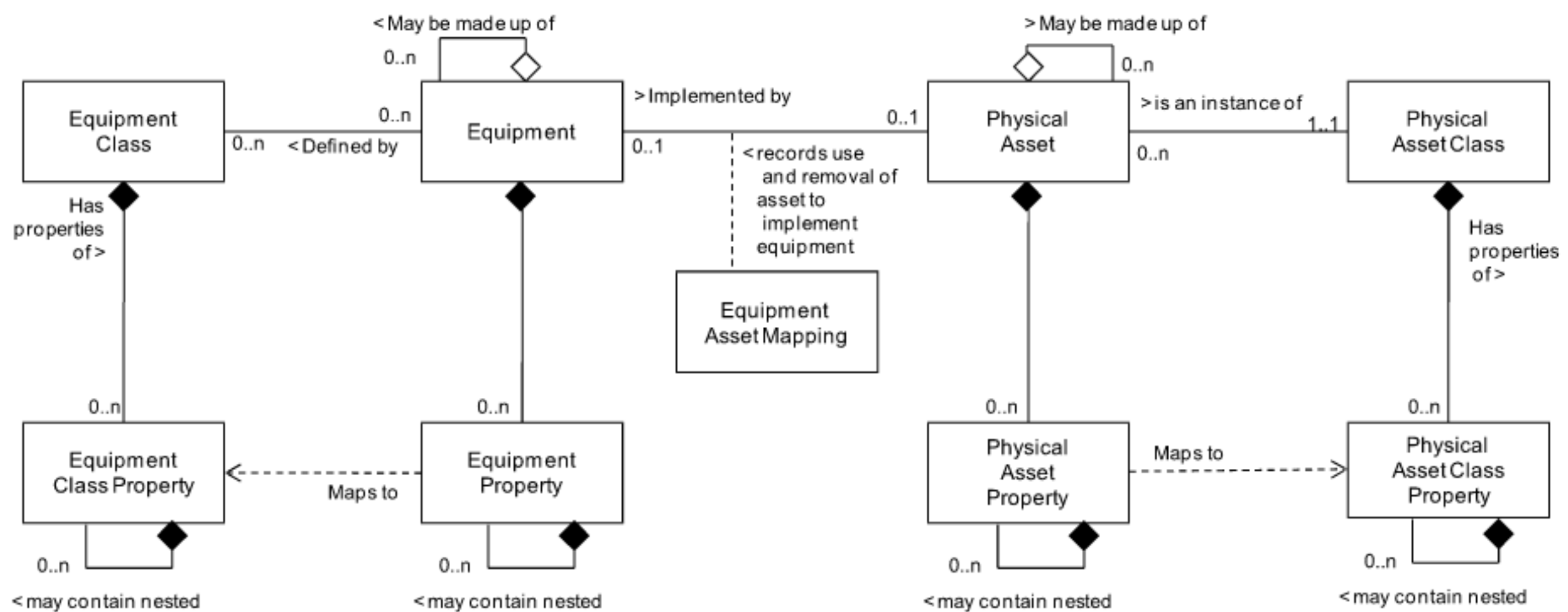


Figure 8 — Physical asset and equipment relationship

NOTE This model shown in Figure 8 is consistent with the MIMOSA data models, but with various name differences due to their development history.

1. A MIMOSA Asset element maps to a Physical Asset object.
2. A MIMOSA Asset Utilization History element maps to an Equipment Asset Mapping object.
3. A MIMOSA Segment element maps to an Equipment object.
4. A MIMOSA Model element maps to a Physical Asset Class object.
5. A MIMOSA Agent element would map to an attribute or property, where needed.

5.3.2 Physical asset

A *physical asset* represents a physical piece of equipment. Table 16 lists the attributes of a *physical asset*. A physical asset may be tested by the execution of a physical asset capability test specification.

Physical assets may be made up of other physical assets. For example, a packaging line may be made up of conveyor sections, motors, and sensors.

Table 16 — Attributes of physical asset

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Defines a unique identification of a <i>physical asset</i> .	SN5246\$9	SN68928#1	SN5247\$3	VIN 55262528
Description	Contains additional information and descriptions of the <i>physical asset</i> .	2 HP Pump	High Performance Welder	Auto titration tester	Fork Truck
Physical Location	Actual physical location of the physical asset	Area 54, Unit 3A	Storage Bay 9982	Floor 2 Lab	Docking Bay 3
Fixed Asset ID	Contains a unique identification for financial tracking as required by laws or regulations	2000291	2000292	2000293	2000294
Vendor ID	Contains a vendor's serial number	AT55628	667y62	W78GJ77	H2228

NOTE 1 Implementations should consider the following rules concerning the use of IDs:

1. The Physical Asset ID should be an enterprise wide identification.
2. If an information exchange is required to handle assets across enterprises, then the ID should be a GUID (Globally Unique ID).
3. Common local practices may require other identifications of physical assets and require additional correlated identifications represented as properties.

NOTE 2 Materials used in maintenance operations may be represented in either the physical asset equipment model, in the material model, or in both. When represented in both models the IDs used to identify the material in both models (Material Lot and Physical Asset ID) should be the same.

5.3.3 Physical asset property

Properties of physical assets shall be listed as physical asset properties. A physical asset shall have zero or more physical asset properties. These specify the current property values of the physical asset for the associated physical asset class property. Physical asset properties may

include a unit of measure. Table 17 lists the attributes of a *physical asset property*. A physical asset property may be tested by the execution of a physical asset capability test specification with results exchanged using a physical asset capability test result.

Physical asset properties may contain nested physical asset properties.

Table 17 — Attributes of physical asset property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific property.	Date of Manufacture	Assembly Drawing	Tracked Physical Asset	Tracked Physical Asset
Description	Additional information about the <i>asset property</i> .	Name plate date of production	Vendor assembly drawing ID	Indicates that the physical asset must be signed out and tracked	Indicates the state of the physical asset
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related <i>asset property</i> .	2008 10	ACC08-55642	<Tracked, Not Tracked,>	<Assigned, Issued, Available>
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Date	String	Boolean	Boolean

5.3.4 Physical asset class

A representation of a grouping of physical assets with similar characteristics for purposes of repair and replacement shall be used as a physical asset class. Any physical asset shall be a member of one physical asset class. Table 18 lists the attributes of a *physical asset class*. A physical asset class may be tested by the execution of a physical asset capability test specification.

Table 18 — Attributes of physical asset class

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Manufacturer	An identification of the manufacturer.	Smith Pumps.	Jones Welders	Franz Testers	Chrysler Fleet Car
ID	The manufacture's identification of the specific <i>physical asset class</i> . For example: the model number	2HPWP	HPWLDR 103	ATT 99	Series K
Description	Additional information about the <i>physical asset class</i> .	Intrinsically Safe	(not applicable)	(not applicable)	(not applicable)

5.3.5 Physical asset class property

Properties of a physical asset class shall be listed as physical asset class properties. Each may have zero or more recognized properties. Table 19 lists the attributes of a *physical asset class property*. A physical asset class property may be tested by the execution of a physical asset capability test specification.

Physical asset class properties may contain nested physical asset class properties.

Table 19 — Attributes of physical asset class property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific property.	Throughput	Weld Rate	Test Speed	Charge Time
Description	Additional information about the <i>property</i> .	Pump Throughput	Maximum speed of welder	Average test rate	Hours to recharge truck
Value	The value, set of values, or range of the property. The value(s) is assumed to be within the range or set of defined values for the related <i>asset property</i> .	400	5	1315	5
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	L / Min	cm / Second	Samples / Hour	Hours

5.3.6 Physical asset capability test specification

A representation of a capability test for a physical asset shall be represented as a physical asset capability test specification. A physical asset capability test specification may be associated with a physical asset property. This is typically used where a test is required to ensure that the physical asset has the rated capability and capacity. A physical asset capability test specification may test for one or more physical asset properties. Table 20 lists the attributes of a *physical asset capability test specification*.

A physical asset capability test specification shall include

- an identification of the test;
- a version of the test;
- a description of the test.

Table 20 — Attributes of physical asset capability test specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific physical asset capability test specification.	WPTT82	WR9	ATT00029	CTIME 99
Description	Additional information about the <i>test specification</i> .	Test of Pump Throughput	Test of Maximum speed of welder	Test of Average test rate	Test of Hours to recharge truck
Version	An identification of the version of the capability test specification.	00	1	2	3

5.3.7 Physical asset capability test result

The results from a qualification test for a specific physical asset shall be represented as a physical capability test result. Table 21 lists the attributes of a *physical asset capability test result*.

A physical asset capability test result shall include

- the date of the test;
- the result of the test (passed-failed or quantitative result);
- the expiration date of the test.

Table 21 — Attributes of physical asset capability test result

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific physical asset capability test result.	CPT-999	MT- 998	HD-878	IN-BX-7778
Description	Additional information about the <i>test result</i> .	the number of chrome plated widgets produced per hour	pH meter calibration result test	Hardness test of unit 878	Cold box storage temp. delta
Date	The date and time of the capability test.	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30	1999-10-25 13:30
Result	The result of the capability test.	48	7.0001	<Pass, Fail>	1.2
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	Widgets/Hour	pH	Boolean	°C
Expiration	The date of the expiration of the capability.	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30	2000-10-25 13:30

5.3.8 Equipment asset mapping

The relationship between a physical asset and an equipment shall be represented as an equipment asset mapping. Table 22 lists the attributes of an *equipment asset mapping*. The equipment asset mapping records the time period when one equipment object and one physical asset object were associated.

Table 22 — Attributes of equipment asset mapping

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific equipment asset mapping.	111	112	113	114
Description	Additional information about the <i>mapping</i> element.	(not applicable)	Installed under work order 48423. Removed under work order 93823	(not applicable)	(not applicable)
Start Time	The starting time of the association.	1997-02-10	1997-02-10	2004-04-23	2005-04-30
End Time	The ending time of the association.	2004-12-10	2004-12-10	(not applicable)	(not applicable)

5.4 Material information

5.4.1 Material model

The material model shown in Figure 9 defines the actual materials, material definitions, and information about classes of material definitions. Material information includes the inventory of raw, finished, intermediate materials, and consumables. The information about planned or actual material is contained in the material lot and material subplot information. Material classes are defined to organize materials.

NOTE This corresponds to a resource model for material, as defined in ISO 10303.

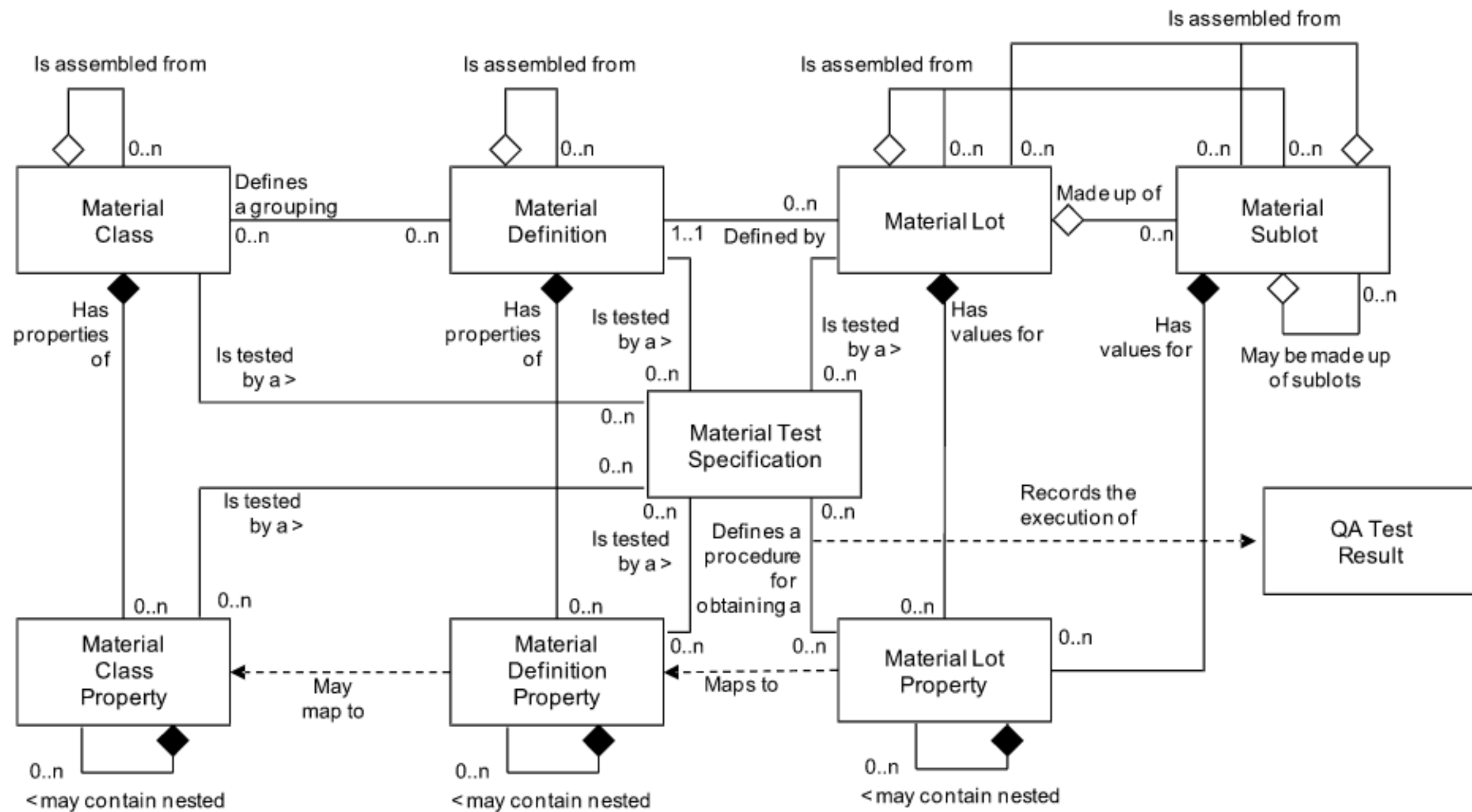


Figure 9 — Material model

5.4.2 Material class

A material class is a representation of groupings of material definitions for a definite purpose such as manufacturing operations definition, scheduling, capability and performance. Table 23 lists the attributes of *material class*. A material class may be tested by the execution of a material test specification.

NOTE An example of a material class may be sweetener, with members of fructose, corn syrup, and sugar cane syrup. Another example of a material class may be water, with members of city water, recycled water, and spring water.

A material definition shall belong to zero or more material classes.

Table 23 — Attributes of material class

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific <i>material class</i> , within the scope of the information exchanged (<i>production capability</i> , <i>production schedule</i> , <i>production performance</i> , ...) The ID shall be used in other parts of the model when the <i>material class</i> needs to be identified, such as the <i>production capability</i> for this <i>material class</i> , or a <i>production response</i> identifying the <i>material class</i> used.	Polymer sheet stock 1001A	200 cP Oil (SAE 90)	RH5510	20 mil Wrap
Description	Additional information about the <i>material class</i> .	Solid polymer resin	Very High Viscosity Lubricating Oil	Oxidizing Agent	Wrap used to wrap pallets
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

A material class may be defined as containing an assembly of material classes and as part of an assembly of material classes:

1. A material class may define an assembly of zero or more material classes.
2. A material class may be an assembly element of zero or more material classes.
3. An assembly may be defined as a permanent or transient assembly of material classes.
4. An assembly may be defined as physical or a logical assembly of material classes.

5.4.3 Material class property

Properties of a material class shall be presented as material class properties. A material class shall be further characterized through zero or more material class properties. Table 24 lists the attributes of material class property. A material class property may be tested by the execution of a material test specification.

Material class properties may contain nested material class properties.

NOTE Examples of material class properties include density, pH factor, and material strength.

The material class properties often list the nominal, or standard, values for the material. A material property does not have to match a material class property.

Table 24 — Attributes of material class property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a specific <i>material class property</i> .	Polyethylene sheet thickness	Oil Viscosity	pH	Weight
Description	Additional information about the <i>material class property</i> .	Sheet Thickness	Coefficient of viscosity	Acidity	Weight to be added to shipping label
Value	The value, set of values, or range of the property.	{5, 10, 25}	(not applicable)	{0..7}	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm	Pa-s	pH	g / m ²

5.4.4 Material definition

A representation of goods with similar name characteristics for the purpose of manufacturing operations definition, scheduling, capability and performance shall be shown as a material definition. Table 25 lists the attributes of *material definition*. A material definition may be tested by the execution of a material test specification.

NOTE Examples of these may be city water, hydrochloric acid and grade B aluminum.

Any material lot shall be associated with one material definition.

Table 25 — Attributes of material definition

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific <i>material definition</i> , within the scope of the information exchanged (<i>production capability</i> , <i>production schedule</i> , <i>production performance</i> , ...) The ID shall be used in other parts of the model when the <i>material definition</i> needs to be identified, such as the <i>production capability</i> for this <i>material definition</i> , or a <i>production response</i> identifying the <i>material definition</i> used.	Sheet stock 1443a	DO200cpO	OA9929	PW882929
Description	Additional information about the <i>material definition</i> .	General purpose sheet stock	200 cP Oil from Dino Oil	Oxidizing Agent from RustItAll	General purpose 20 mil wrap
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

A material definition may be defined as containing an assembly of material definitions and as part of an assembly of material definitions:

1. A material definition may define an assembly of zero or more material definitions.
2. A material definition may be an assembly element of zero or more material definitions.
3. An assembly may be defined as a permanent or transient assembly of material definitions.
4. An assembly may be defined as physical or a logical assembly of material definitions.

5.4.5 Material definition property

Properties of a material definition shall be defined as material definition properties. A material definition shall be further characterized through zero or more material definition properties.

Table 26 lists the attributes of *material definition property*. A material definition property may be tested by the execution of a material test specification.

Material definition properties may contain nested material definition properties.

NOTE Examples of material definition property include density, pH factor, or material strength.

Properties may present the nominal or standard values for the material.

Table 26 — Attributes of material definition property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific material definition property.	1443a5mm	Oil Viscosity	pH	Weight
Description	Additional information about the <i>material definition property</i> .	5 millimeter sheet	Coefficient of viscosity	Acidity	Weight to be added to shipping label
Value	The value, set of values, or range of the property.	{4.85 .. 5.15}	{250 x 10 ⁻³ .. 255 x 10 ⁻³ }	{3.99 .. 4.01}	20 .. 21
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm	Pa-s	pH	g / m ²

5.4.6 Material lot

A representation of a uniquely identified specific amount of material, either countable or weighable shall be named as a material lot. A material lot describes the planned or actual total quantity or amount of material available, its current state, and its specific property values. Table 27 lists the attributes of *material lot*. A material lot may be tested by the execution of a material test specification.

A material lot shall include

- a unique identification of the lot;
- the amount of material (count, volume, weight);
- the unit of measure of the material (for example, parts, liters, kg);
- a storage location for the material;
- any status of the lot.

A material lot may be made up of material sublots. Material lots and material sublots may be used for traceability when they contain unique identifications.

Table 27 — Attributes of material lot

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific <i>material lot</i> , within the scope of the information exchanged (<i>production capability, production schedule, production performance, ...</i>) The ID shall be used in other parts of the model when the <i>material lot</i> needs to be identified, such as the <i>production capability</i> for this <i>material lot</i> , or a <i>production response</i> identifying the <i>material lot</i> used.	L66738-99	L8828-81	L53920-02	L8626-33
Description	Additional information about the material lot.	PlastiFab 10/31 shipment	Oil	Reagent	Wrapping material
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit. Note 2 If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot, as defined in Part 1 of this standard, not an assembly.	Permanent	Transient	Permanent	Transient
Status	Status of the <i>material lot</i> . For example, released, approved, blocked, in process, in quality check.	In process	approved	blocked	approved
Storage Location	An identification of the storage location or a physical location of the <i>material lot</i> .	Work Center 1	Maintenance Shed 4S	Work Bench 10, Top Shelf	Warehouse 1
Quantity	The quantity of the <i>material lot</i> .	1200	20	1	41
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	sheets	Cans	Liter	Rolls

NOTE 1 Representation of non-lot controlled items (for example consumable materials or bulk materials), may be represented in the Material Lot model through the use of a unique IDs for each different Material Definition. For example this could be the Material Definition ID or a system assigned ID,

NOTE 2 If non-lot controlled items must be maintained in multiple locations then the information may be represented in the Material Sublot model through the use of unique sublot IDs for each different location and Material Definition.

A material lot or a material sublot may be defined as containing an assembly of material lots or material sublots and as part of an assembly of material lots or material sublots:

1. A material lot or a material sublot may define an assembly of zero or more material lots or a material sublots.
2. A material lot or a material sublot may be an assembly element of zero or more material lots or a material sublots.
3. An assembly may be defined as a permanent or transient assembly of material lots or sublots.

EXAMPLE 1 A transient assembly could be a temporary collection of material maintained as a batch kit on a pallet, the batch kit is identified with a unique identification and may contain specific properties, such as a pallet identification, location, and related batch ID.

EXAMPLE 2 A permanent assembly of material may be an automobile. The automobile has a unique vehicle identification number (VIN) and other properties. The automobile may contain an assembly of an engine, transmission, chassis, and wheels, each with their own unique identification and properties.

4. An assembly may be defined as physical or a logical assembly of material or sublots. Assemblies of materials do not imply a manufacturing status.

EXAMPLE 3 A finished tractor is a physical assembly of materials.

EXAMPLE 4 An unassembled collection of tractor components that are separately shipped is a logical assembly of materials.

5.4.7 Material lot property

Each material can have unique values for zero or more material lot properties, such as a specific pH value for the specific lot of material, or a specific density for the lot of material. A material lot property may be tested by the execution of a material test specification with results exchanged in a QA test specification result.

Material lot properties may contain nested material lot properties.

A material lot property is associated with either a material lot or a material sublot. When associated with a material lot it specifies a property value for all sublots, when associated with a material sublot it specifies a property value for a single sublot.

Table 28 lists the attributes of *material lot property*.

Table 28 — Attributes of material lot property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the specific <i>material lot property</i> .	Average sheet thickness	Oil Viscosity	pH	Weight
Description	Additional information about the <i>material lot property</i> .	Measured thickness	Coefficient of viscosity	Acidity	Weight to be added to shipping label
Value	The value, set of values, or range of the property.	5.002	250×10^{-3}	4.01	20.3
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm	Pa-s	pH	g / m^2

5.4.8 Material subplot

A material lot may be stored in separately identifiable quantities. Each separately identifiable quantity of the same material lot shall be presented as a material subplot. All material sublots are part of the same material lot, so they have the material lot's property values. A material subplot may be just a single item. Table 29 lists the attributes of *material subplot*. Material sublots may have subplot specific properties.

Material subplot properties may contain nested material subplot properties.

EXAMPLE Sublot properties may be RFID tag IDs or other identification properties, such that each subplot of a lot has a different property value.

Each material subplot shall contain the location of the subplot and the quantity or amount of material available in the subplot.

Material sublots may contain other sublots.

NOTE For example, a subplot may be a pallet, each box on the pallet may also be a subplot, and each material blister pack in the box may also be a subplot.

A material subplot shall include

- a unique identification of the subplot;
- the storage location of the subplot;
- the unit of measure of the material (for example, parts, kg, tons);
- any status of the subplot.

Table 29 — Attributes of material subplot

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific <i>material subplot</i>, within the scope of the information exchanged (<i>production capability, production schedule, production performance ...</i>) The ID shall be used in other parts of the model when the <i>material subplot</i> needs to be identified, such as the <i>production capability</i> for this <i>material subplot</i>, or a <i>production response</i> identifying the <i>material subplot</i> used.	1999-10-27-a67-B6653	L8828-81-S1	L53920-02-A554	L8626-33-2
Description	Additional information about the <i>material subplot</i> .	Pallet 2 of 6	Oil	Reagent	Wrapping material
Assembly Type	Optional Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit. Note 2 If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot, as defined in Part 1 of this standard, not an assembly.	Permanent	Transient	Permanent	Transient
Status	Status of the current <i>material subplot</i> . For example, released, approved, blocked, in process, in quality check.	Released	approved	blocked	approved
Storage Location	An identification of the storage location or a physical location of the <i>material subplot</i> .	Stainless Steel Tote #57	Maintenance Shed 4S, Top Shelf	Work Bench 10, Top Shelf	Warehouse 1
Quantity	The quantity of the <i>material subplot</i> .	40	10	1	41
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	sheets	Cans	Liter	Rolls

5.4.9 Material test specification

A representation of a material test shall be shown as a material test specification. A material test specification shall be associated with one or more material definition properties. This is typically used where a test is required to ensure that the material has the required property value. A material test specification may identify a test for one or more material definition properties. Not all properties need to have a defined material test specification. Table 30 lists the attributes of *material test specification*.

Material test specifications may also be related to a production request. The same material may have different specifications for different production requests, depending on specific customer requirements.

A material test specification shall include

- a) an identification of the test;
- b) a version of the test;
- c) a description of the test.

Table 30 — Attributes of material test specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a test for certifying one or more values for one or more <i>equipment properties</i> . For example, this may be the name of a document that describes or lists the capability test.	STMT-101	MI330	QA8899	67
Description	Additional information about the <i>Material Test Specification</i> .	Sheet thickness measurement test – returns the average sheet thickness based on a sample plan and technique for a specific lot	Test of water content in an oil	Check of vendor's COA on pH.	Check of vendor's COA for weight or wrapping material
Version	An identification of the version of the <i>Material Test Specification</i> .	1.0	1.0	2.1	A.1

5.4.10 Material test result

A representation of the results from the execution of a quality assurance test shall be presented as a material test result. A material test result records the results from a material test for a specific material lot or material subplot. The following are some characteristics of material test results. Table 31 lists the attributes of *material test result*.

- a) They shall be related to a material lot or material subplot.
- b) They may be related to a production request.
- c) They may be associated with a specific production response.
- d) They may be related to a specific process segment.

- e) They may include a pass/fail status of the test.
- f) They may include quantitative information of the tests.
- g) They may include the granting or refusing of an in-process or finished goods waiver request.
- h) They may be related to a product characteristic.

Material test results may be associated with a specific production response.

Table 31 — Attributes of material test result

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique instance identification that records the results from the execution of a test identified in a <i>material test specification</i> for a lot or subplot. (For example, this may just be a number assigned by the testing authority.)	THK101/01-10-2000	MO998	7763	u7373
Description	Additional information about the <i>Material Test Result</i> .	Results from thickness test for PlastiFab lot on 1999-10-25	Test of metal content in oil	Test of water pH	Check of expiration date
Date	The date of the material test.	1999-10-25 11:30	2008-01-23	2008-01-20	2008-01-23
Result	The value or list of values returned from the performance of the material test. For example: Pass, Fail, 95, Red, Green.	Pass	20	6.9	Pass
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	<Pass, Fail>	ppm	pH	<Pass, Fail>
Expiration	The date of the expiration of the test results.	2000-10-25 13:30	2008-02-23	(not applicable)	(not applicable)

5.4.11 Assemblies

Assemblies are collections or sets of related elements. Assemblies are represented as relationships between elements and attributes of the elements. Each assembly element has its own identity and properties, such as a material lot which has its own identity and properties. An object with an assembly (*material lot*, *material subplot*, *material class*, and *material definition*) is contains the list of other elements that make up the assembly.

NOTE 1 Many assembly type industries, such as automobile manufacturing, airplane assembly, and furniture manufacturing use the concept of assemblies. A produced material, with a unique identification and properties, is made up of other materials with their own unique identification and properties.

EXAMPLE 1 An “automobile” is a material lot, with specific properties (color, VIN #, make, model, ...) while it also contains other chassis parts (engine, transmission, axles ...) that also have their own unique identification and properties.

EXAMPLE 2 A transaxle in an automobile has its own identification and also is an assembly of subcomponents, as shown in Figure X, including seals, bearing, axle shaft, etc, as shown in Figure 10. There may be an assembly which defines a specific model of transmission described in a *Material Definition Assembly*, and there may be an assembly that defines a specific transmission described in a *Material Assembly*.

EXAMPLE 3 A “batch kit” is an assembly that contains a collection of different materials that would be used in the production of a batch, for example a batch kit for a soup may contain the seasonings that are used in production of a single batch. There may be an assembly which defines the class of materials used in a batch kit described in a *Material Class Assembly*, and there may be a batch specific assembly which defines specific material lots or sublots described in a *Material Assembly*.

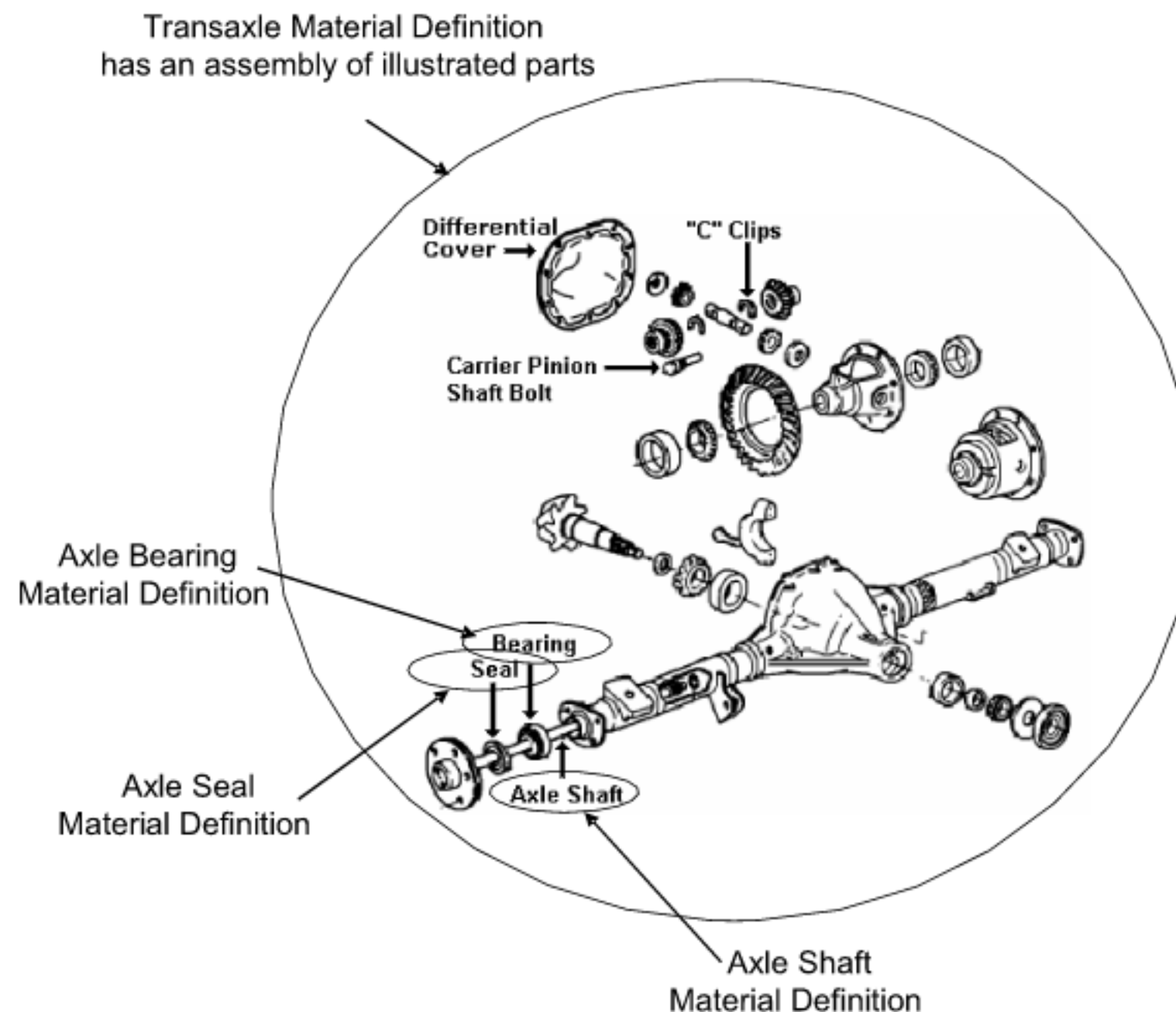


Figure 10 — Example of a material with an assembly

5.5 Process segment information

5.5.1 Process segment model

Process segments are the smallest elements of manufacturing activities that are visible to business processes. The process segment model is a hierarchical model, in which multiple levels of abstraction of manufacturing processes may be defined because there may be multiple business processes requiring visibility to manufacturing activities.

NOTE The term *business process segment* is a synonym for *process segment* and is used to reflect the business process aspect of the process segment.

Process segments are also logical grouping of personnel resources, equipment resources, and material required to perform a manufacturing operations step. A process segment defines the needed classes of personnel, equipment, and material, and/or it may define specific resources, such as specific equipment needed. A process segment may define the quantity of the resource needed.

The manufacturing operations step may be a production operations step, inventory operations step, maintenance operations step, and quality operations step.

Figure 11 is the process segment model.

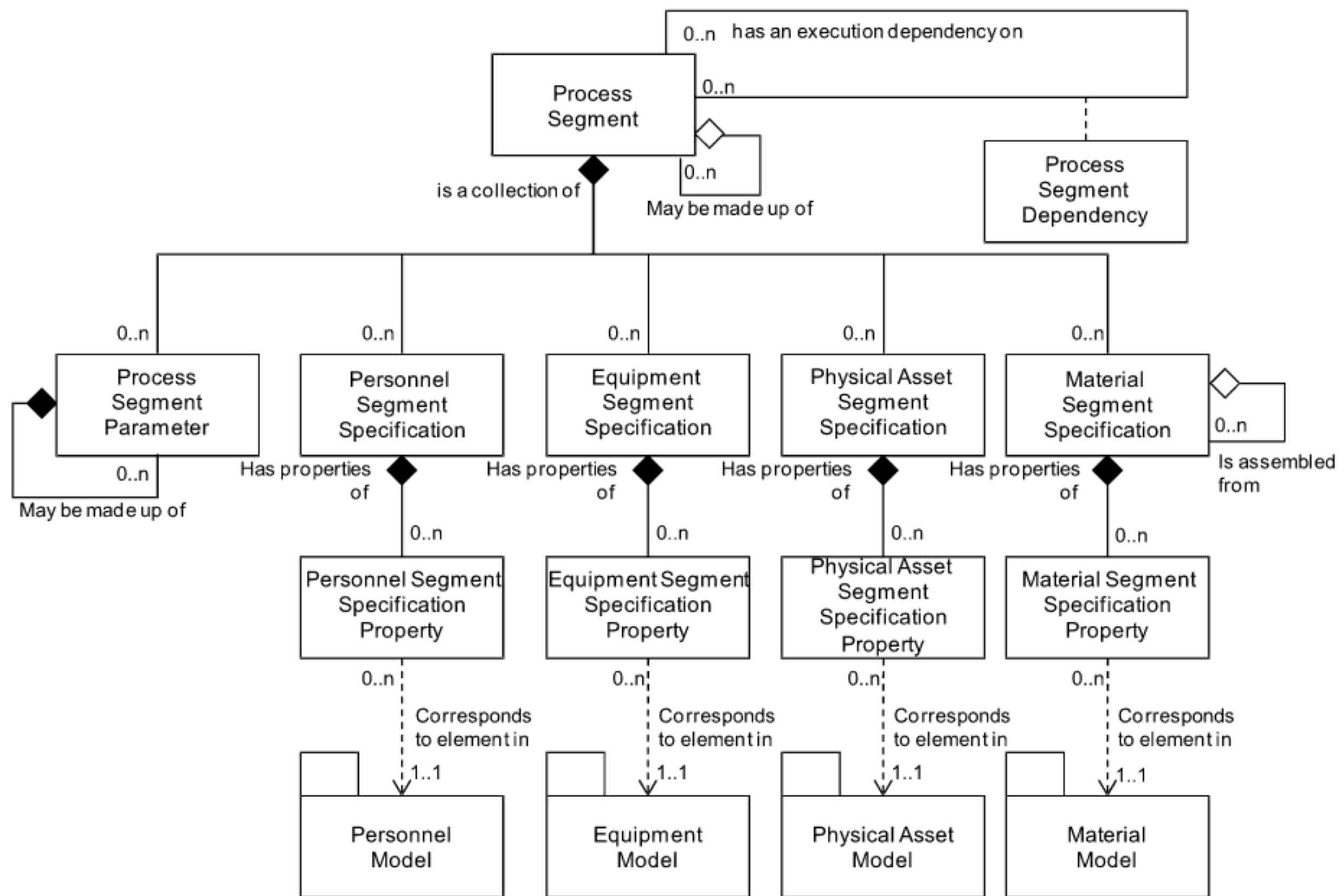


Figure 11 — Process segment model

5.5.2 Process segment attributes

A process segment lists the classes of personnel, equipment, physical assets, and material needed, and/or it may present specific resources, such as specific equipment needed for the process segment. A process segment may list the quantity of the resource needed.

A process segment is something that occurs or can occur during manufacturing operations.

Process segment may identify

- a) the time duration associated with the resource;

NOTE Five hours or 5 hours/100 kg.

- b) constraint rules associated with ordering or sequencing of segments.

A process segment may be made up of other process segments, in a hierarchy of definitions.

Process segments may contain specifications of specific resources required by the Process segment. Process segments may contain parameters that can be listed in specific operations requests.

Table 32 defines the attributes for *process segment* objects.

Table 32 — Attributes of process segment

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a <i>process segment</i>, within the scope of the information exchanged (<i>operations capability</i>, <i>operations schedule</i>, <i>operations performance</i> ...) The ID shall be used in other parts of the model when the <i>process segment</i> needs to be identified, such as the <i>operations capability</i> for this segment, or an <i>operations response</i> identifying the segment.	Widget Frame Milling	Replace Motor	Pull Sample and Run Test	Transfer
Description	Additional information about the <i>process segment</i> .	Frame milling operation, separately costed operation	Large size motor replacement	Check purity and concentration	Move pallet from truck to conveyor system
Operations type	Describes the category of the activity Required attribute. Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. “Mixed” shall be used when the activity contains several categories of process segments.	Production	Maintenance	Quality	Inventory
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. Optionally defines the scope of the process segment definition, such as the site or area it is defined for.	South Shore (Site) / Work Line (Area)	South Shore (SITE) / Packaging (Area)	Mixer Sample Port (Work Unit)	Receiving dock (Work Center)
Duration	Duration of process segment, if known.	25	(not applicable)	20	5
Duration Unit of Measure	The units of measure of the duration, if defined.	Minutes	(not applicable)	minutes	minutes

5.5.3 Personnel segment specification

Personnel resources that are required for a process segment shall be presented as personnel segment specifications.

Table 33 defines the attributes for *personnel segment specification* objects.

Table 33 — Attributes of personnel segment specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Personnel Class	Identifies the associated <i>personnel class</i> or set of <i>personnel classes</i> specified	Milling Machine Operator	Type 2 Mechanic	Lab Tech A	Lift truck operator
Person *	Identifies the associated <i>person</i> or set of <i>persons</i> specified	<n/a>	<n/a>	<n/a>	<n/a>
Description	Contains additional information and descriptions of the <i>personnel segment specification</i> definition.	Defines the time for journeyman milling machine operators for each widget frame milling process segment.	Qualified to replace motor type NEMA 4.	Qualified to operation of reflectometer	Certified lift truck operator
Personnel Use	Defines the expected use of the personnel class or person.	Allocated	Certified	Certified	Allocated
Quantity	Specifies the personnel resource required for the parent <i>process segment</i> , if applicable.	1.3	2	.5	5
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece	Hours / motor	Hours / sample	minutes / transfer

NOTE * Typically only *personnel class* is defined.

5.5.4 Personnel segment specification property

Specific properties that are required are specified in personnel segment specification properties.

Personnel segment specification properties may contain nested personnel segment specification properties.

Table 34 defines the attributes for *personnel segment specification property* objects

Table 34 — Attributes of personnel segment specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>person property</i> or <i>personnel class property</i> .	Height	Scuba Trained	Color Vision	2 nd Shift
Description	Contains additional information and descriptions of the property.	Defines the required minimum height of a milling machine operator.	Class 4 work requires use of scuba underwater	Must distinguish red and green	Must be able to operate 2 nd shift
Value	The value, set of values, or range of the property.	150	TRUE	TRUE	TRUE
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	cm	<True, False>	<True, False>	<True, False>
Quantity	Specifies the personnel resource required, if applicable.	1.3	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece	(not applicable)	(not applicable)	(not applicable)

5.5.5 Equipment segment specification

Equipment resources that are required for a process segment shall be presented as equipment segment specifications.

Table 35 defines the attributes for *equipment segment specification* objects.

Table 35 — Attributes of equipment segment specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Equipment Class	Identifies the associated <i>equipment class</i> or set of <i>equipment classes</i> of the capability.	(not applicable)	10 Ton Crane	Reflectometer	800 kg Fork Truck
Equipment*	Identifies the associated <i>equipment</i> or set of <i>equipment</i> of the capability.	Milling Machine 001	(not applicable)	(not applicable)	(not applicable)
Description	Contains additional information and descriptions.	Equipment needed for widget milling process segment	Crane required to remove motor	Measures substrate thickness of wafer	Able to lift two standard pallets
Equipment Use	Defines the expected use of the equipment class or equipment in the context of the process segment.	Part Milling	Remove and Replace Motor	Run Test	Material Movement
Quantity	Specifies the amount of resources required, if applicable.	1.3	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Machine Hours / piece	Day	Test	Move

NOTE * Typically either *equipment class* or *equipment* is defined.

5.5.6 Equipment segment specification property

Specific properties that are required are specified in equipment segment specification properties.

Equipment segment specification properties may contain nested equipment segment specification properties.

Table 36 defines the attributes for *equipment segment specification property* objects.

Table 36 — Attributes of equipment segment specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>equipment property</i> or <i>equipment class property</i> .	Milling Direction	Mobile	Calibrated	Power
Description	Contains additional information and descriptions.	Only vertical milling machines are suitable for widget milling.	Mobile crane	Within calibrated date	Type of power
Value	The value, set of values, or range of the property. For example: Vertical, Horizontal	Vertical	TRUE	TRUE	Electric
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	<True, False>	<True, False>	{Electric, Gas, LP}
Quantity	Specifies the amount of resources required.	1.0	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Machine Hours / piece	(not applicable)	(not applicable)	(not applicable)

5.5.7 Material segment specification

Material resources that are required for a process segment shall be listed as material segment specifications.

Table 37 defines the attributes for *material segment specification* objects.

Table 37 — Attributes of material segment specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Material Class	Identifies the associated <i>material class</i> or set of <i>material classes</i> of the capability.*	Polymer sheet stock 1001A	Motor Brushes	Sample Holder	Pallet
Material Definition	Identifies the associated material definition or set of <i>material definitions</i> of the capability. *	Sheet stock 1443a	#9949	Polyurethane sample holder	Plastic Pallet
Description	Contains additional information and descriptions.	Defines the polymer required for a widget milling process segment.	Brushes required during motor maintenance	Disposable sample holder	Pallet used for storage
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
Material Use	Defines the material use. For production defined values are: Consumable, Material Consumed, and Material Produced	Material Consumed	Material Consumed	Material Consumed	Material Consumed
Quantity	Specifies the amount of resources required.	0.35	6	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	Sheets / piece	Units	Units	(not applicable)

NOTE * Typically either a *material class* or *material definition* is specified.

A material segment specification may be defined as containing an assembly of material segment specifications and as part of an assembly of material segment specifications:

1. A material segment specification may define an assembly of zero or more material segment specifications.
2. A material segment specification may be an assembly element of zero or more material segment specifications.
3. An assembly may be defined as a permanent or transient assembly of material segment specifications.

4. An assembly may be defined as physical or a logical assembly of material segment specifications.

5.5.8 Material segment specification property

Specific properties that are required are specified in material segment specification properties.

Material segment specification properties may contain nested material segment specification properties.

Table 38 defines the attributes for *material segment specification property* objects.

Table 38 — Attributes of material segment specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>material property</i> or <i>equipment class property</i> .	Average Surface Roughness	314 Stainless Steel	Sterilized	RFID
Description	Contains additional information and descriptions.	Defines the minimum polyethylene roughness quality.	Required alloy	Sterilized sample holder	Pallet contains an active RFID
Value	The value, set of values, or range of the property.	66.748	TRUE	TRUE	Active
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Angstroms	<True, False>	<True, False>	<Active, Passive, None>
Quantity	Specifies the amount of resources required, if applicable.	0.10	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	Sheets / piece	(not applicable)	(not applicable)	(not applicable)

5.5.9 Physical asset segment specification

Physical asset resources that are required for a process segment shall be presented as physical asset segment specifications.

Table 39 defines the attributes for *physical asset segment specification* objects.

Table 39 — Attributes of physical asset segment specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Physical Asset Class	Identifies the associated <i>physical asset class</i> or set of <i>physical asset classes</i> of the capability.	Acme Super TT10	Easy bake 1969	Wafers R Us RF 100	SuperTote 2000
Physical Asset	Identifies the associated <i>physical asset</i> or set of <i>physical assets</i> of the capability.	TI-101	OV-1200	RF-140	Tote 12A
Description	Contains additional information and descriptions.	Transmitter with most recent calibration date	Oven with minimum 2000 hours on run clock	Measures substrate thickness of wafer	Able to store 200 vials in 40 x 5 matrix
Physical Asset Use	Defines the expected use of the physical asset class or physical asset in the context of the process segment.	Temperature of granulation process	Preventive maintenance	Thickness measurement	Storage
Quantity	Specifies the amount of resources required, if applicable.	1	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	°K	hours	micron	Cubic feet

5.5.10 Physical asset segment specification property

Specific properties that are required are specified in physical asset segment specification properties.

Physical asset segment specification properties may contain nested physical asset segment specification properties.

Table 42 defines the attributes for *physical asset segment specification property* objects.

Table 40 — Attributes of physical asset segment specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>physical asset property</i> or <i>physical asset class property</i> .	Temperature calibration date	Run clock	Calibrated	Tote Type
Description	Contains additional information and descriptions.	Calibration date no later than 6 months from use	Running time hours from last preventive maintenance	Within calibrated date	Only plastic totes
Value	The value, set of values, or range of the property. For example: Vertical, Horizontal	1999-12-31	1200	True	Plastic
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Date	Hours	<True, False>	String
Quantity	Specifies the amount of resources required.	(not applicable)	(not applicable)	(not applicable)	3
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	(not applicable)	(not applicable)	(not applicable)	Count

5.5.11 Process segment parameter

Specific parameters required for a segment shall be shown as process segment parameters.

Process segment parameters may contain nested process segment parameters.

Table 41 defines the attributes for *process segment parameter* objects.

Table 41 — Attributes of process segment parameter

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Identification of the <i>process segment parameter</i> .	Milling Time	Crane Lead Time	Sample Size	Number of Pallets
Description	Contains additional information.	Range of acceptable milling times.	Known lead time to get crane available	Size of sample to be pulled	Number of pallets needed for move
Value	The value, set of values, or range of acceptable values	{5..10}	{1..20}	{5-20}	(not applicable)
Unit of Measure	Unit of measure of the values, if applicable.	Minutes	Days	mg	(not applicable)

5.5.12 Process segment dependency

Table 42 defines the attributes for *process segment dependency* objects. The *process segment dependencies* can be used to describe process dependencies that are independent of any particular product or operations task.

NOTE 1 For example, a process segment dependency may define that an testing segment must follow an assembly segment.

Table 42 — Attributes of process segment dependency

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	The identification of the unique instance of the <i>process segment dependency</i> .	PSD001	34	A35	PSA-I-5563
Description	Contains additional information and descriptions of the <i>process segment dependency</i> definition.	Defines the ordering of assembly processes the Widget Assembly process segment	Don't start until production is complete	May pull samples anytime during production	Don't move to storage until released by quality
Dependency Type	Defines the execution dependency constraints of one segment by another segment	Start <i>Cleanout</i> no earlier than T (<i>Timing Factor</i>) after <i>Work</i> end	Start <i>Motor Replacement</i> after <i>Cleanout</i> end	<i>Pull Sample</i> may run in parallel with <i>MIX</i>	<i>Move Inventory</i> after <i>Quality Release</i>
Dependency Factor	Factor used by dependency	25	(not applicable)	(not applicable)	(not applicable)
Unit of Measure	The units of measure of the dependency factor, if defined.	Minutes	(not applicable)	(not applicable)	(not applicable)

EXAMPLE Using 'A' and 'B' to identify the process segments, or specific resources within the segments, and T to identify the timing factor, as shown in Figure 12, the dependencies include:

- B can not follow A
- B may run in parallel to A
- B may not run in parallel to A
- Start B at A start
- Start B after A start
- Start B after A end
- Start B no later than T (Dependency Factor with time T) after A start
- Start B no earlier than T (Dependency Factor with time T) after A start
- Start B no later than T (Dependency Factor with time T) after A end
- Start B no earlier than T (Dependency Factor with time T) after A end

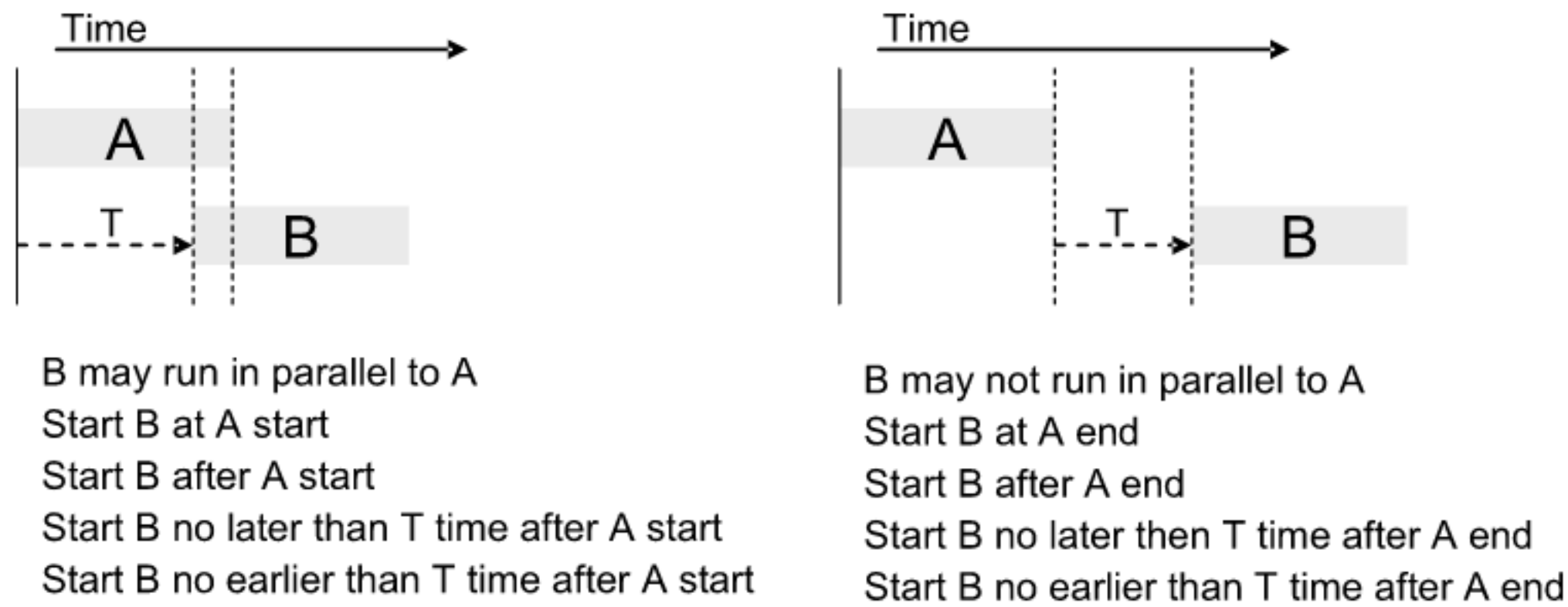


Figure 12 – Segment dependency examples

NOTE 2 The associations to the A and B segments are not represented as attributes, as per 4.5.6.

6 Operations management information

6.1 Operations definition information

6.1.1 Operations definition model

Operations definition shall be used to specify the resources required to perform a specified operation. The operations definition may apply to defining production, maintenance, quality test and inventory operations. The actual definition of how to perform the operation is not included in the object model. Figure 13 below is the common operations definition model.

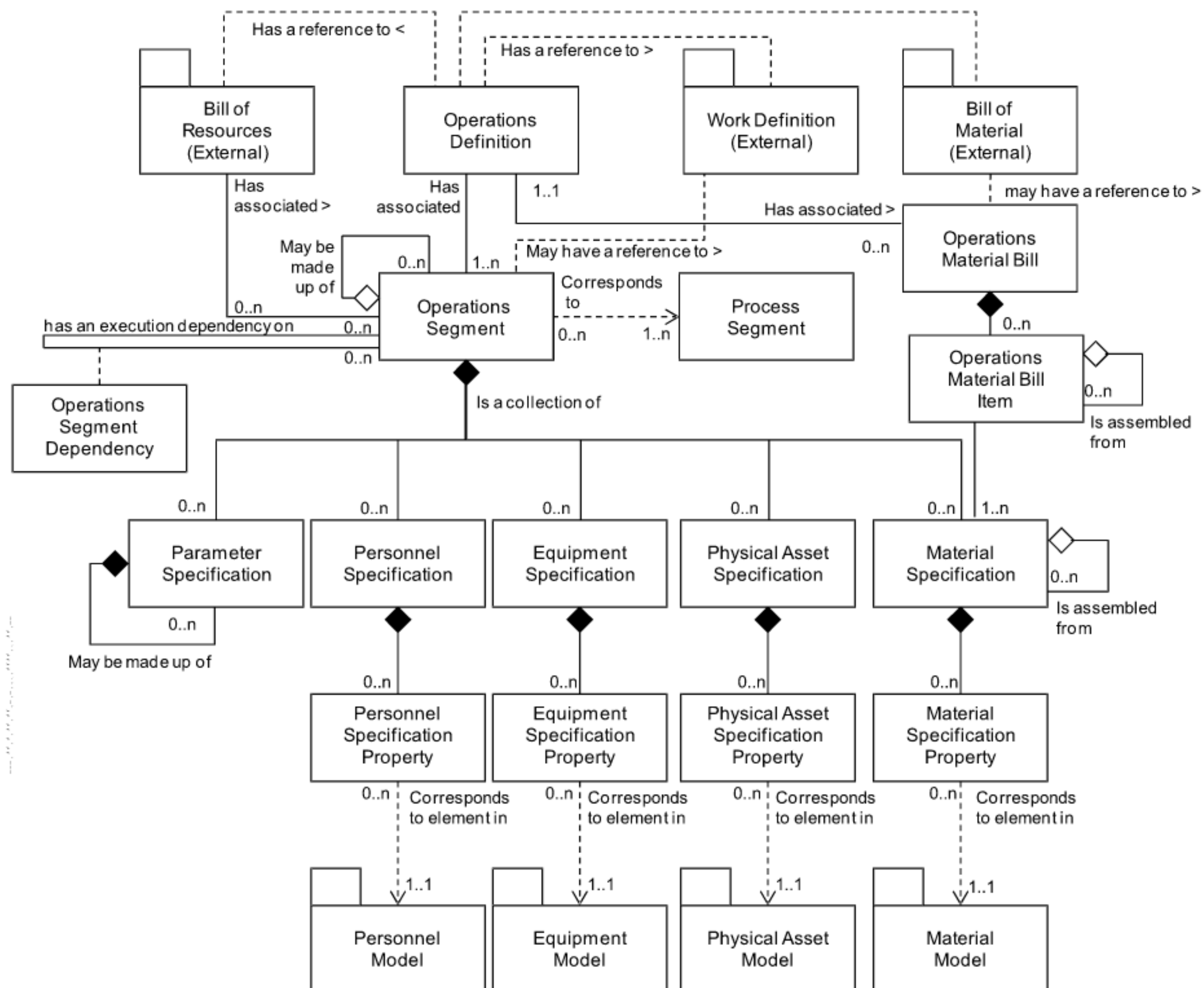


Figure 13 — Operations definition model

Operations instructions are defined as the information used to instruct a manufacturing operation how to perform the operation. Production operations specific operations instructions may be called a general, site or master recipe (IEC 61512-1 and ANSI/ISA-88.01-1995 definition), standard operating procedure (SOP), standard operating conditions (SOC), master or product routing, or assembly steps based on the production strategy used.

6.1.2 Operations definition

Table 43 defines the attributes for *operations definition* objects.

Table 43 — Attributes of operations definition

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Uniquely identifies the operations definition. The ID shall be used in other parts of the model when the <i>Operations definition</i> needs to be identified	Export Quality Widget	Medium Size AC Motor Overhaul	Potency Test Procedure	Tank Transfer Procedure
Version	An identification of the version of the <i>Operations definition</i> . In cases where there are multiple versions of an <i>Operations definition</i> , then the version attribute shall contain the additional identification information to differentiate each version.	1.0	1.4	1.1	1.1
Description	Contains additional information and descriptions of the <i>Operations definition</i>	Information defining resources required for production of a single 'Export Quality Widget'.	For overhauls of motors less than 200 HP.	Test for potency of product	Movement of material from one tank to another
Operations type	Describes the category of operation Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when the operations definition contains several types of operations requests and/or segment requirements	Production	Maintenance	Quality	Inventory
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing(AREA)/ Manufacturing Line #2(WORK CENTER)	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Bill of Material ID	Identification of the external Bill Of Material associated with this Operation Definition	BOM9929	BOM9928	BOM9927	BOM9926
Work Definition ID	Identification of the external Work Definition associated with this Operations Definition	WD009 V0.23	WD008 V03	WD007 V1.3	WD006
Bill of Resource ID	Identification of the external Bill Of Resource associated with this Operation Definition	BOR77782 V01	BOR77783	BOR77784 V11	BOR77785 V3.45

NOTE 1 In the case of production, an Operations Definition ID may be the same ID as a Material Definition.

NOTE 2 A product definition, as defined in Part 1, is the equivalent of an Operations Definition for production.

NOTE 3 A MIMOSA *Solution Package* is the equivalent of an Operations Definition for maintenance.

6.1.3 Operations material bill

Table 45 defines the attributes for *operations material bill* objects. Operations material bill objects define the collection of all material used in the operation independent of the segment the material is used in.

There may be multiple operations material bills, with different uses.

Example: There may be one operations material bill for consumed materials and a second operations material bill for produced materials.

Table 44 — Attributes of operations material bill

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a <i>manufacturing bill</i> .	10000	552619	Q123AC3	755433
Description	Contains additional information of the <i>manufacturing bill</i> .	All materials required in the manufacturing process for a single widget.	Silicon Base Bearing Grease	Chart Paper	Pallet

6.1.4 Operations material bill item

Table 45 defines the attributes for *operations material bill item* objects. Operations material bill item objects identify the items that make up the complete operations material bill.

Table 45 — Attributes of operations material bill item

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a <i>bill</i> item.	10000827	552619	Q123AC3	755433
Description	Contains additional information of the <i>bill</i> item.	All materials required in the manufacturing process for a single widget.	Silicon Base Bearing Grease	Chart Paper	Pallet
Material Class	Identifies the associated <i>material class</i> or set of <i>material classes</i> required.	{Polymer sheet stock 1001A, Rivets}	Fred's Bearing, Grease	Circular Chart Paper	4x4 pallet
Material Definition	Identifies the associated <i>material definition</i> or set of <i>material definitions</i> required.	{Sheet stock 1443a , Rivet-10002}	{20 mm Bearing, NLGI Grade 2 Grease}	10" diameter circular chart paper	1000 lb Weight load 4x4 pallet
Use type	Defines the use of the material. Example 1: Consumed – indicates that bill items are all consumed material. Example 2: Produced – indicates that bill items are all produced materials.	Consumed	Consumed	Consumed	Consumed
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient
Quantity	Specifies the amount of resources required.	{1.0, 26}	{2, 30}	5	100
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	{Sheets / piece, Number / piece}	{piece, ml}	Each	Each

An operations material bill item may be defined as containing an assembly of operations material bill items and as part of an assembly of operations material bill items:

1. An operations material bill may define an assembly of zero or more operations material bills.
2. An operations material bill may be an assembly element of zero or more operations material bills.

3. An assembly may be defined as a permanent or transient assembly of operations material bills.
4. An assembly may be defined as physical or a logical assembly of operations material bills.

6.1.5 Operations segment

The information needed to quantify a segment for a specific operation shall be an operations segment. An operations segment identifies, references, or corresponds to a process segment.

Table 46 defines the attributes for *operations segment* objects.

Table 46 — Attributes of operations segment

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific segment within the scope of the information exchanged. The ID shall be used in other parts of the model when the segment needs to be identified.	Final Polished Widget	200 HP AC Motor Disassemble	120VAC Meter Test 001	Line 1 Raw Material Stage
Description	Contains additional information of the segment	A brightly polished widget.	Disassembly of motor prior to rebuild	Test range of volt meter	Material staging for shift
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing(AREA)	Asset ID 13465	Test Cell 4	Warehouse B
Duration	Duration of segment, if known.	25 Minutes	4	15	30
Duration Unit of Measure	The units of measure of the duration, if defined.	Minutes	Hours	Seconds	Minutes
Process segment	Identifies the associated Process segments. There may be multiple alternate process segments that could be used for the operations segment.	Widget Polishing	AC Motor Disassemble	Volt Meter Test	Raw Material Stage
Operations type	Describes the category of operation. Required attribute. Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when the operations segment contains several types of operations requests and/or segment requirements.	Production	Maintenance	Quality	Inventory
Work Definition ID	Identification of the external Work Definition associated with this Operations Segment	WD009 V0.23	WD008 V03	WD007 V1.3	WD006

NOTE 1 A MIMOSA *ordered list* is the equivalent of an operations segment for maintenance operations.

NOTE 2 A MIMOSA *ordered list resource item* is the equivalent of a single item personnel specification, equipment specification, physical asset specification or material specification for a maintenance operations segment.

NOTE 3 A product segment is the equivalent of an operations segment for production operations. See Annex A.

6.1.6 Parameter specification

An operations segment may have an associated set of zero or more parameter specifications. The parameter specification contains the names and types of the values that may be sent to the Level 3 systems to parameterize the operation.

Parameter specifications may contain nested parameter specifications.

NOTE Examples of parameter specifications are pH of 3,5, pressure limit of 35 psi, and flange color = orange.

Parameter specifications shall include

- a) an identification of the parameter;
- b) the units of measure of the parameter value.

Parameter specifications should include

- 1) a default value for the parameter or;
- 2) possible ranges of the parameter value

EXAMPLE Ranges may be alarm or quality ranges; tolerances for acceptable parameter values.

Table 47 defines the attributes for *parameter specification* objects.

Table 47 — Attributes of parameter specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Identification of the <i>parameter</i> for a specific segment.	Widget roughness	Torque Value	Viscometer spindle size	Cases per pallet
Description	Contains additional information of the <i>parameter</i> .	Range of acceptable surface roughness to be manufactured.	Maximum torque value for fly wheel assembly	Spindle size for correct viscosity range	Number of cases per pallet
Value	The value, set of values, or range of acceptable values	{80..2500}	35	2	124
Value Unit of Measure	Unit of measure of the values, if applicable.	Angstroms	Nm	cP	Each

6.1.7 Personnel specification

An identification, reference, or correspondence to a personnel capability shall be presented as a personnel specification. A personnel specification usually specifies personnel class but may specify a person. This identifies the specific personnel capability that is associated with the identified operations segment or product segment.

A personnel specification shall include

- a) an identification of the personnel capability needed;
- b) the quantity of the personnel capability needed;

c) the unit of measure of the quantity.

Specific elements associated with a personnel specification may be included in one or more personnel specification properties.

NOTE Examples of personnel specification properties are training level required, specific skill required, and exposure availability.

Table 48 defines the attributes for *personnel specification* objects.

Table 48 — Attributes of personnel specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Personnel Class	Identifies the associated <i>personnel class</i> or set of <i>personnel classes</i> of the specification for a specific segment.	Widget Polisher	Diesel mechanic grade 2	Lab Tech II	warehouse manager
Person	Identifies the associated <i>person</i> or set of <i>persons</i> of the specification for a specific segment.	999-12-3456	DMG2 422	LT-101	999-99-9999
Description	Contains additional information of the <i>personnel specification</i> .	Polisher skill required for export quality polished widget	Certified Diesel mechanic for heavy equipment	Level 2 certified quality technician	Schedules line side inventory deliveries in terms of this segment
Personnel Use	Defines the expected use of the personnel class or person.	Allocated	Allocated	Allocated	Allocated
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable.	0.25	2	1	0.0001
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	person hours	People	Tech	Man years

6.1.8 Personnel specification property

Table 49 defines the attributes for *personnel specification property* objects.

Personnel specification properties may contain nested personnel specification properties.

Table 49 — Attributes of personnel specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>person property</i> or <i>personnel class property</i> for a specific segment.	Polishing Certification Level	Grade 2 Diesel mechanic	Lab Tech II	warehouse manager
Description	Contains additional information and descriptions of the <i>personnel specification property</i> definition.	Level of polishing skill certification required for the widget polisher	Level of skill required to work on diesel engine	Level of skill required to operate lab instrument	Level of skill required to manage warehouse scheduling
Value	The value, set of values, or range of the property. For example: Apprentice, Journeyman, Master	Master	Level 2	Level 2 certified quality technician	MBA
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	{Apprentice, Journeyman, Master}	Skill Level	Skill Level	Degree
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable.	0.10	2	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece	People	Tech	Manager

6.1.9 Equipment specification

An identification, reference, or correspondence to an equipment capability shall be used as an equipment specification. An equipment specification may specify either an equipment class or a piece of equipment. This identifies the specific equipment capability that is associated with the segment.

An equipment specification shall include

- an identification of the equipment capability needed either as the equipment class needed or specific equipment;
- the quantity of the equipment capability needed;
- the unit of measure of the quantity.

Specific elements associated with an equipment specification may be included in one or more equipment specification properties.

NOTE Examples of equipment specification properties are material of construction, maximum material capacity, and minimum heat extraction amount.

Table 50 defines *equipment specification* object.

Table 50 — Attributes of equipment specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Equipment Class	Identifies the associated <i>equipment class</i> or set of <i>equipment classes</i> of the specification for a specific segment.	Widget Polishing Machine	Drill	GCMS	5000 LB CAP SS containme nt vessel
Equipment	Identifies the associated <i>equipment</i> or set of <i>equipment</i> of the specification for a specific segment.	WPM-10	18 VDC Hand Drill #5	GCMS-#1001	VC#5
Description	Contains additional information and descriptions of the <i>equipment specification</i>	Equipment required to polish Export Quality Widgets.	Battery operated drill required for remote, manual task	Gas chromatog raph for analyzing volatiles	Intermedia te bulk container
Equipment Use	Defines the expected use of the equipment class or equipment.	Part finishing	Assembly setup	%VOC Test result	Raw material staging
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable.	0.5 {shared between two segments}	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Each	Each	Each	Each

6.1.10 Equipment specification property

Table 51 defines the attributes for *equipment specification property* object.

Equipment specification properties may contain nested equipment specification properties.

Table 51 — Attributes of equipment specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>equipment property</i> or <i>equipment class property</i> for a specific segment.	Voltage Rating	Chuck Size	Carrier Gas	Stainless Steel Type
Description	Contains additional information and descriptions of the <i>equipment specification property</i> definition.	The voltage rating required for operation	The range of the chuck	The carrier gas used to carry the sample	The type of SS
Value	The value, set of values, or range of the property. For example: Wet, Dry	190 ~ 240	20 to 40	He	316
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Volts	mm	<n/a>	Compositi on
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable.	n/a	2	0.5	n/a
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	n/a	Each	L	n/a

6.1.11 Physical asset specification

An identification, reference, or correspondence to a physical asset capability shall be used as a physical asset specification. A physical asset specification may specify either a physical asset or a physical asset class. This identifies the specific physical asset capability that is associated with the segment.

An physical asset specification shall include

- an identification of the physical asset capability needed either as the physical asset class needed or physical asset;
- the quantity of the physical asset capability needed;
- the unit of measure of the quantity.

Specific elements associated with an physical asset specification may be included in one or more physical asset specification properties.

Table 52 defines *physical asset specification* object.

Table 52 — Attributes of physical asset specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Physical asset class	Identifies the associated <i>Physical Asset Class</i> or set of <i>Physical Asset Classes</i> of the specification for a specific segment.	Polishing Machine	Torque Wrench	GCMS	IBC
Physical Asset	Identifies the associated <i>physical asset</i> or set of <i>physical assets</i> of the specification for a specific segment.	20090121	100 N-m Torque Wrench	Model GCMS100	Model IBC-SS-5K
Description	Contains additional information and descriptions of the <i>physical asset specification</i>	Polisher	Wrench used for specific torque rating	Used to measure VOC conc.	Stainless Steel 5000 lb capacity
Physical Asset Use	Defines the expected use of the physical asset class or physical asset.	Polish	Wrench required for proper tightening of motor head	Gas Chromatography test	Raw material staging
Quantity	Specifies the amount of physical asset resources required for the parent segment, if applicable.	1.25	2	1	5000
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Minutes / piece	Each	Each	Each

6.1.12 Physical asset specification property

Table 53 defines the attributes for *physical asset specification property* object.

Physical asset specification properties may contain nested physical asset specification properties.

Table 53 — Attributes of physical asset specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>physical asset property</i> or <i>physical asset class property</i> for a specific segment.	Polisher Type	Torque range	Min. detectable concentration	Opening type
Description	Contains additional information and descriptions of the <i>physical asset specification property</i> definition.	Wet polisher required for fine polishing.	Min-Max torque ratings	Sensitivity of the detector	top bung opening
Value	The value, set of values, or range of the property. For example: Wet, Dry	Wet	10-80	< 1	Top bung
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	ft. lbs.	ppm	(not applicable)
Quantity	Specifies the amount of physical asset resources required for the parent segment, if applicable.	0.10	1	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Minutes / piece	each	(not applicable)	(not applicable)

6.1.13 Material specification

An identification or correspondence to a material capability shall be presented as a material specification. A material specification specifies a material or a material class. This identifies the specific material specification that is associated with the identified product segment.

A material specification shall include

- a) an identification of the material needed;
- b) the quantity of the material needed;
- c) the unit of measure of the quantity.

Specific elements associated with a material specification may be included in one or more material specification properties.

NOTE Examples of material specification properties are colour range, density tolerance, and maximum scrap content.

Table 54 defines *material specification* objects.

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Table 54 — Attributes of material specification

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Material Class	Identifies the associated <i>material class</i> or set of <i>material classes</i> of the specification for a specific segment.*	Abrasives	Impeller	Reference gas	Bung
Material Definition	Identifies the associated <i>material definition</i> or set of <i>material definitions</i> of the specification for a specific segment.*	Rouge	Motor-Impeller Subassembly	Nitrous Oxide 10 ppm	2" bung
Description	Contains additional information and descriptions of the <i>material specification</i> .	Polishing material for Export Quality Widget polishing.	Replacement impeller	Calibration gas	4x2 304 Stainless Steel bung
Material Use	Defines the material use: Material Consumed, Material Produced, or Consumable	Consumable	Consumable	Consumable	Consumable
Quantity	Specifies the amount of material resources required for the parent segment, if applicable.	10	1	1.5	1
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	gm / piece	each	Liter	Each
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

NOTE * Typically either a *material class* or *material definition* is specified.

A material specification may be defined as containing an assembly of material specifications and as part of an assembly of material specifications:

1. A material specification may define an assembly of zero or more material specifications.
2. A material specification may be an assembly element of zero or more material specifications.
3. An assembly may be defined as a permanent or transient assembly of material specifications.

4. An assembly may be defined as physical or a logical assembly of material specifications.

6.1.14 Material specification property

Table 55 defines the attributes for *material specification property* object.

Material specification properties may contain nested material specification properties.

Table 55 — Attributes of material specification property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>material property</i> for a specific segment.	Grit Size	Pitch	Purity	Material of Construction
Description	Contains additional information and descriptions of the <i>material specification property</i> .	Measure of required grit size for Export Quality Widget polishing.	Percentage of blade length per angle of progression	Reference gas concentration	MOC
Value	The value, set of values, or range for the associated property.	{1300..1500}	16-21	+/_ 500	304 Stainless Steel
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Grit Number	Pitch	ppb	Grade
Quantity	Specifies the amount of material resources required for the parent segment, if applicable.	5	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	gm / piece	(not applicable)	(not applicable)	(not applicable)

6.1.15 Operations segment dependency

Table 56 defines the attributes for *operations segment dependency* objects. The *operations segment dependencies* can be used to describe dependencies that are operation or product specific.

EXAMPLE 1 A wheel assembly and a frame assembly can run in parallel.

Table 56 lists the attributes of an operations segment dependency.

Table 56 — Attributes of operations segment dependency

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	The identification of the unique instance of the <i>operations segment dependency</i> .	PSD001	34	A35	PSA-I-5563
Description	Contains additional information and descriptions of the <i>operations segment dependency</i> definition for a specific segment.	Defines the sequencing of widget washing during the Widget Assembly product segment	Defines the sequence for replacing an impeller	Defines sampling sequence	Defines IBC sealing
Dependency Type	Defines the execution dependency constraints of one segment by another segment.	Start <i>Acid Addition</i> no later than <i>T (Timing Factor)</i> after <i>Reaction Complete</i> end	Start disassembly after lock-out and tag-out segments are complete	Start calibration gas X minutes after purge gas ends	Insert and secure bung after IBC filling complete
Dependency Factor	Factor used by dependency	25	<True, False>	50	<True, False>
Unit of Measure	The units of measure of the dependency factor, if defined.	Minutes	Boolean	Minutes	Boolean

EXAMPLE 2 Dependency type using A and B to identify the segments, or specific resources within the segments, and T to identify the timing factor, as shown in Figure 12, include the following:

- B can not follow A
- B may run in parallel to A
- B may not run in parallel to A
- Start B at A start
- Start B after A start
- Start B after A end
- Start B no later than T (Dependency Factor with time T) after A start
- Start B no earlier than T (Dependency Factor with time T) after A start
- Start B no later than T (Dependency Factor with time T) after A end
- Start B no earlier than T (Dependency Factor with time T) after A end

NOTE The associations to the A and B segments are not represented as attributes, as per clause 4.5.6.

6.2 Operations schedule information

6.2.1 Operations schedule model

A request for operations to be performed shall be listed as an operations schedule. An operations schedule shall be made up of one or more operations requests.

The operations schedule may apply to scheduling of Production, Maintenance, Quality Test and Inventory.

Figure 14 is the operations schedule model.

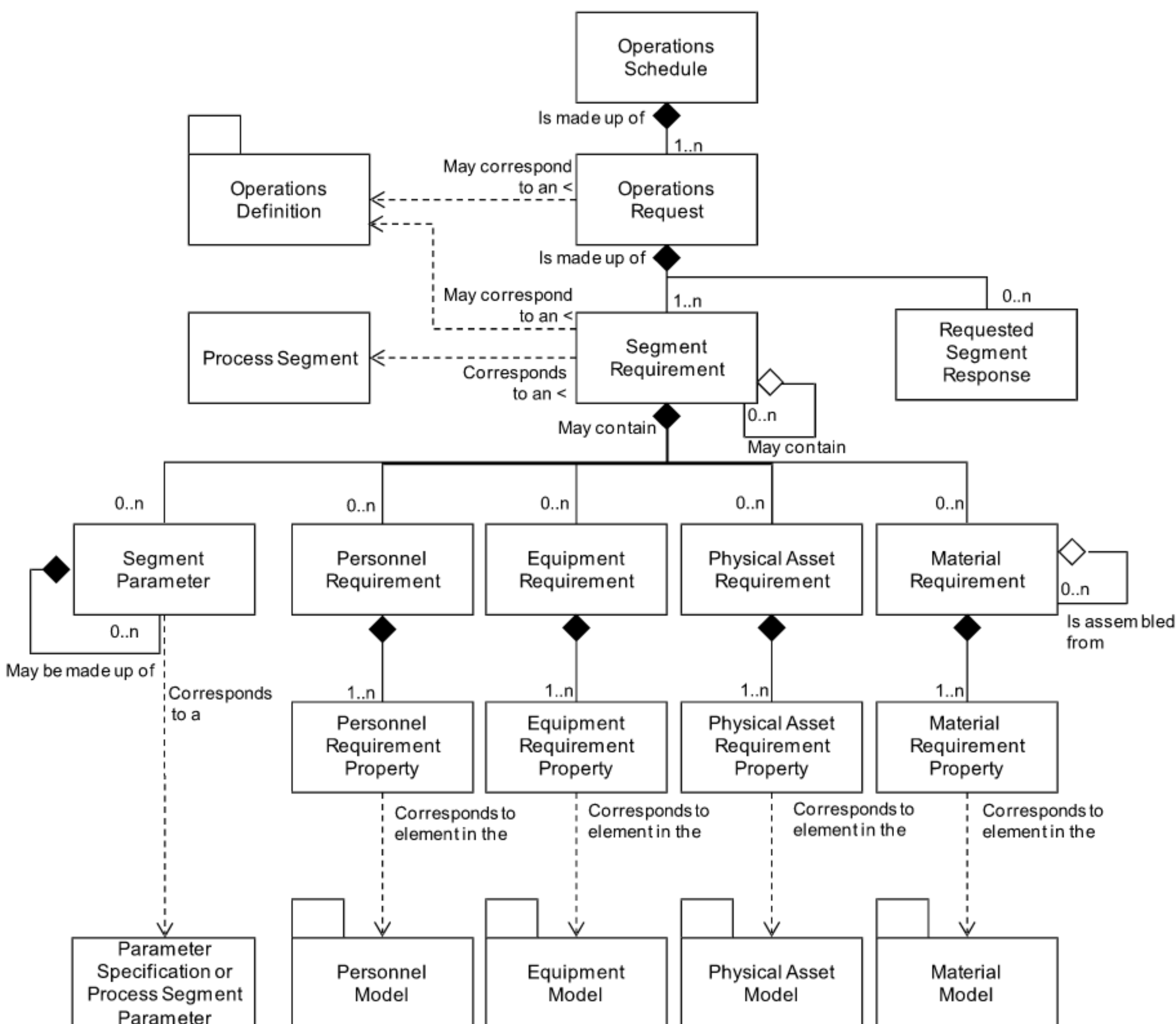


Figure 14 — Operations schedule model

6.2.2 Operations schedule

A request for operations to be performed shall be listed as an operations schedule. An operations schedule shall be made up of one or more operations requests.

An operations schedule may be defined for any specific category of operations; production, maintenance, quality, or inventory, or it may be defined for a combination of categories. When a combination is selected, then the operations requests or segment requirement specifies the category of the operation.

Table 57 defines the attributes for *operations schedule* object.

Table 57 — Attributes of operations schedule

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of the <i>operations schedule</i> and could include version and revision identification. The ID shall be used in other parts of the model when the <i>operations schedule</i> needs to be identified.	PMMFUF	MWOIDND	QNFKVUV	IECBDU
Description	Contains additional information and descriptions of the <i>operations schedule</i> .	Widget manufacturing schedule	Daily Planned Maintenance	Widget raw material testing schedule	Widget raw material staging schedule
Operations type	Describes the category of operation. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, and Mixed. “Mixed” shall be used when the operations schedule contains several types of operations requests and/or segment requirements.	Production	Maintenance	Quality	Inventory
Start Time	The starting time for the associated <i>operations schedule</i> , if applicable.	10-28-2006	10-27-2006	10-28-2006	10-28-2006
End Time	The ending time for the associated <i>operations schedule</i> , if applicable.	10-30-2006	10-31-2006	10-30-2006	10-30-2006
Published Date	The date and time on which the <i>operations schedule</i> was published or generated.	10-17-2006 18:30 UTC	10-17-2006 18:30 UTC	17 Oct 2006 18:30 UTC	10-17-2006 18:30 UTC
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing(AREA)/ Manufacturing Line #2(WORK CENTER)	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Scheduled State	Indicates the state of the operations schedule. Defined values are: Forecast and Released. Forecast - The requirements have not been released for use. Example: This may be a schedule which is an estimate of a future schedule to allow long-term planning by the receiver, with a later "Released" schedule when the schedule has been approved and released to production.) Released - The requirements have been released for use.	Released	Forecast	Released	Released

NOTE A MIMOSA *Segment Request for Work* and an *Asset Request for Work* are the equivalent of an operations request for either equipment or for a physical asset. The table of *Request for Work* is the equivalent of the Operations schedule.

6.2.3 Operations request

A request for an element of an operation schedule shall be shown as an operations request. An operations request contains the information required by manufacturing to fulfill the scheduled operation. This may be a subset of the business information, or it may contain additional information not normally used by the business system.

An operations request may identify or reference the associated operations instructions. An operations request shall contain at least one segment requirement, even if it spans all of the operation.

An operations request may include

- when to start the operation, typically used if a scheduling system controls the schedule;
- when the operation is to be finished, typically used if the manufacturing operations system controls its internal schedule to meet deadlines;
- the priority of the request, typically used if exact ordering of production is not externally scheduled;

An operations request may be reported on by one or more operations responses. Additional information may be described in the production parameters, personnel requirements, equipment requirements, and material requirements.

Table 58 defines the attributes for *operations request* objects.

Table 58 — Attributes of operations request

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of the <i>operations request</i> . The ID shall be used in other parts of the model when the <i>operations request</i> needs to be identified.	1001091	59328AC8	E938723	KIT493
Description	Contains additional information and descriptions of the <i>operations request</i> .	Operations request for export quality widgets for October 29, 1999.	Daily maintenance request	Test incoming materials	Prepare kit for production run
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, and Mixed. “Mixed” shall be used when the operations request contains several types of operations requests.	Production	Maintenance	Quality	Inventory
Start Time	When operation is to be started, if applicable.	1999-10-27 8:00 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 2:00 UTC
End Time	When operation is to be completed, if applicable.	1999-10-27 17:00 UTC	10-28-2006 2:30 UTC	10-28-2006 4:30 UTC	10-28-2006 4:00 UTC
Priority	The priority of the request, if applicable.	Highest	1	B	High
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Operations Definition ID	Identifies the associated <i>Operations definition</i> to be used, if applicable.	Export Quality Widget	CNC Daily Maintenance Procedure	T48323	BOM for Export Quality Widget
Request State	Indicates the state of the operations request. Defined values are: Forecast and Released. Forecast - The requirements have not been released for use. Released - The requirements have been released for use.	Released	Forecast	Released	Released

6.2.4 Segment requirement

A process segment and a production request shall be made up of one or more segment requirements. Each segment requirement shall correspond to, or reference, an identified operations segment or process segment. The segment requirement identifies or references the segment capability to which the associated personnel, equipment, materials, and segment parameters correspond.

The personnel requirement property, equipment requirement property and product parameter shall align with the personnel property, equipment property, and product parameters sent as part of a production request. If the scheduling function sends information that is not understood by the receiving control function, then that information cannot be used within the control function. Likewise the scheduling function has to be able to determine what information can be accepted by the control function.

Table 59 defines the attributes for *segment requirement* object.

Table 59 — Attributes of segment requirement

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of the <i>segment requirement</i> within the scope of an operations <i>request</i> .	A6646	KU492	48283	4883DV
Description	Contains additional information and descriptions of the <i>segment requirement</i> .	Polishing segment, containing specifications for personnel, materials and equipment.	Test program to verify X-Y coordinates within calibration	Verify stock dimensions	Pull part from warehouse, tag, and forward stage
Operations type	Describes the category of operation. Required attribute. Defined values are: Production, Maintenance, Quality, Inventory, and Mixed.	Production	Maintenance	Quality	Inventory
Segment	An identification of the segment associated with the <i>segment requirement</i> , if applicable.	Polishing Segment	Run X-Y test	RMT38283	Kiting segment
Earliest Start Time	The expected earliest start time of this <i>segment requirement</i> , if applicable.	10-28-2006 4:00 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 4:00 UTC
Latest End Time	The expected latest ending time of this <i>segment requirement</i> , if applicable.	10-28-2006 10:00 UTC	10-28-2006 2:15 UTC	10-28-2006 4:30 UTC	10-28-2006 6:30 UTC
Duration	The expected duration of this segment requirement, if applicable. Note, this should match the associated segment duration.	15	4	.5	2.5
Duration Unit of Measure	The unit of measure of the duration, if applicable.	Minutes	Minutes	Hours	Hours
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Operations Definition ID	Identifies the associated <i>Operations definition</i> to be used, if applicable.	Export Quality Widget	CNC Daily Maintenance Procedure	T48323	BOM for Export Quality Widget

EXAMPLE There may be multiple segments defined. There is one master segment that applies to the entire operations request. The master segment is made up of multiple nested segments for individually specified and reported segments.

NOTE Information that applies across all segments of the operations request, such as a customer name, may be represented as a segment parameter in the master segment. Information that applies to specific segments may be specified as part of the segment.

6.2.5 Segment parameter

Information contained in the enterprise system that is required by the operation system for correct manufacturing shall be known as segment parameters.

A segment parameter shall include

- a) an identification of the parameter that matches parameter specification of the operations definition, such as target acidity;
- b) a value for the parameter, such as 3,4;
- c) the unit of measure of the parameter, such as pH.

A segment parameter should include a set of limits that apply to any change to the value, such as quality limits and safety limits.

Segment parameters may contain nested segment parameters.

Table 60 defines the attributes for *segment parameter* objects.

Table 60 — Attributes of segment parameter

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	The identification of the <i>segment parameter</i> .	Widget roughness	Test hole location tolerance	Thickness	Staging location
Description	Contains additional information and descriptions of the <i>segment parameter</i>	Range of acceptable surface roughness to be manufactured.	Range of acceptable hole locations	Thickness of stock sheets	Forward staging location for production use
Value	The value, set of values, or range of the value to be used for this parameter.	{80..2500}	+/- .01	5	East Wing Manufacturing Line #2
Value Unit of Measure	The engineering units in which the value is defined, if applicable.	Angstroms	cm	mm	{not applicable}

6.2.6 Personnel requirement

The identification of the number, type, duration, and scheduling of specific certifications and job classifications needed to support the current operations request shall be identified as a personnel requirement. Properties of the personnel requirement shall be identified as personnel requirement properties.

NOTE 1 Examples of job classification types include mechanics, operators, health and protection, and inspectors.

NOTE 2 For example, there may be a requirement for one operator with a specified level of certification available 2 h after production starts. There would be one personnel requirement for the requirement for the operator and two personnel requirement properties, one for the certification level and one for the time requirement.

A personnel requirement shall include

- a) the identification of the personnel needed, such as milling machine operator;
- b) the quantity of personnel needed.

Specific elements associated with each personnel requirement may be included in one or more personnel requirement properties.

NOTE Examples of personnel requirement property elements are training and certification, specific skill, physical location, seniority level, exposure level, training certification, security level, experience level, physical requirements, and overtime limitations and restrictions.

Table 61 defines the attributes for *personnel requirement* objects.

Table 61 — Attributes of personnel requirement

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Personnel Class	Identifies the associated <i>personnel class</i> or set of <i>personnel classes</i> of the requirement for a specific <i>segment requirement</i> .	Widget Polisher	CNC operator	Quality Assurance Tech	Warehouse worker
Person	Identifies the associated <i>person</i> or set of <i>persons</i> of the requirement for a specific <i>segment requirement</i> . Typically either <i>personnel class</i> or <i>person</i> is specified, but not both.	Gidget	Charlie Goode	(not applicable)	Joe Wurzelbacher
Description	Contains additional information and descriptions of the <i>personnel requirement</i> .	Defines the specific polishing operator assigned to this operations request.	Trained CNC operator	Quality personnel trained in stock inspections	Person to assemble the kit
Personnel Use	Defines the expected use of the personnel class or person.	Allocated	Certified	Certified	Uncertified
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable. Applies to each member of the <i>person</i> and <i>personnel class</i> sets.	1	1	1	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Full Time Equivalents	Full Time Equivalents	Full Time Equivalent s	Full Time Equivalent s

6.2.7 Personnel requirement property

Table 62 defines the attributes for *personnel requirement property* objects.

Personnel requirement properties may contain nested personnel requirement properties.

Table 62 — Attributes of personnel requirement property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>person property</i> or <i>personnel class property</i> for a specific <i>segment requirement</i> .	Polishing Certification Level	CNC daily maintenance certification	Stock receiving inspection certification	Steel toed shoes
Description	Contains additional information and descriptions of the <i>personnel requirement property</i> definition.	Level of polishing skill certification required for the widget polisher	Training level required	Must have current certification	PPE required
Value	The value, set of values, or range of the property. For example: Apprentice, Journeyman, Master	Journeyman	<True, False>	<True, False>	<True, False>
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Boolean	Boolean	Boolean
Quantity	Specifies the amount of the property required for the parent personnel requirement, if applicable.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	(not applicable)	(not applicable)	(not applicable)	(not applicable)

6.2.8 Equipment requirement

The identification of the number, type, duration, and scheduling of specific equipment and equipment classifications or equipment constraints needed to support the current operations request shall be used as an equipment requirement. Properties of the equipment requirement shall be identified as equipment requirement properties. The operations request may include one or more equipment requirements. Requirements can be as generic as materials of construction, or as specific as a particular piece of equipment. Each of these requirements shall be an instance of the equipment requirement class.

Each equipment requirement identifies a general class of equipment (such as reactor vessels), a specific class of equipment (such as isothermal reactors), or a specific piece or set of equipment (such as isothermal reactor #7). The specific requirements on the equipment, or equipment class are listed as equipment requirement property objects.

An equipment requirement shall include

- c) the identification of the equipment needed, such as milling machine;
- d) the quantity of equipment needed.

Specific elements associated with each equipment requirement may be included in one or more equipment requirement properties.

NOTE Examples of equipment requirement properties are material of construction and minimum equipment capacity.

Table 63 defines the attributes for *equipment requirement* objects.

Table 63 — Attributes of equipment requirement

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Equipment Class	Identifies the associated <i>equipment class</i> or set of <i>equipment classes</i> of the requirement for a specific <i>segment requirement</i> .	Widget Polishing Machine	CNC Drill Press	Micrometer	Bar code scanner
Equipment	Identifies the associated <i>equipment set</i> of <i>equipment</i> of the requirement for a specific <i>segment requirement</i> . Typically either <i>equipment class</i> or <i>equipment</i> is specified, but not both.	WPM-19	DP-1	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the <i>equipment requirement</i>	Specifies the expected machine to be used for this operations request.	Automated drill press	Measurement tool	Warehouse bar code scanner
Equipment Use	Defines the expected use of the equipment class or equipment.	Production	Repair	Testing	Transport
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable. Applies to each member of the <i>equipment</i> and <i>equipment class</i> sets.	1	1	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Units	Machine	Tool	Tool
Equipment Level	A definition of the level of the associated element of the equipment model. For example: enterprise, site, area, unit, Equipment module, Control Module	Production Line	Work Center	{not applicable}	(not applicable)

6.2.9 Equipment requirement property

Table 64 defines the attributes for *equipment requirement property* objects.

Equipment requirement properties may contain nested equipment requirement properties.

Table 64 — Attributes of equipment requirement property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>equipment property</i> or <i>equipment class property</i> for a specific <i>segment requirement</i> .	Polisher Type	Spindle run-out	Scale definition	Portable with LED
Description	Contains additional information and descriptions of the <i>equipment requirement property</i> definition.	Polisher required for this operations request.	Max allowed spindle run-out	Units of measure	Type description
Value	The value, set of values, or range of the associated property. For example: Wet, Dry	Dry	less than 0.00008	Metric	<True, False>
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Inches	{not applicable}	Boolean
Quantity	Specifies the amount of equipment property required for the parent equipment requirement, if applicable.	1	{not applicable}	1	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Units	{not applicable}	Each	Each

6.2.10 Physical asset requirement

The identification of the number, type, duration, and scheduling of specific physical assets and physical asset class constraints needed to support the current operations request shall be used as a physical asset requirement.

Properties of the physical asset requirement shall be identified as physical asset requirement properties. The operations request may include one or more physical asset requirements. Requirements can be as generic as materials of construction, or as specific as a particular piece of physical asset. Each of these requirements shall be an instance of the physical asset requirement class.

A physical asset requirement shall include

- the identification of the physical asset needed, such as milling machine serial number #345334;
- the quantity of physical asset needed.

Specific elements associated with each physical asset requirement may be included in one or more physical asset requirement properties.

NOTE Examples of physical asset requirement properties are material of construction and minimum physical asset capacity.

Table 65 defines the attributes for *physical asset requirement* objects.

Table 65 — Attributes of physical asset requirement

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Physical Asset Class	Identifies the associated <i>physical asset model</i> or set of <i>physical asset models</i> of the requirement for a specific <i>segment requirement</i> .	{not applicable}	Model 105, XYZ Corp, CNC Drill Press	{not applicable}	{not applicable}
Physical Asset	Identifies the associated <i>physical asset</i> or set of <i>physical assets</i> of the requirement for a specific <i>segment requirement</i> . Typically either <i>physical asset</i> or <i>physical asset class</i> is specified, but not both.	{not applicable}	Serial #: 5563442 Asset ID: 44Q56W	{not applicable}	{not applicable}
Description	Contains additional information and descriptions of the <i>physical asset requirement</i> .	{not applicable}	Cameroon Drill Press	{not applicable}	{not applicable}
Physical Asset Use	Defines the expected use of the physical asset class or physical asset.	{not applicable}	Calibrate	{not applicable}	{not applicable}
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable. Applies to each member of the <i>physical asset</i> and <i>physical asset class</i> sets.	{not applicable}	1	{not applicable}	{not applicable}
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	{not applicable}	Machine	{not applicable}	{not applicable}
Equipment Level	A level definition for the associated element in the hierarchy of the physical asset model	{not applicable}	Work Center	{not applicable}	{not applicable}

EXAMPLE The following are maintenance examples for Physical Asset Use:

Repair	Very frequent action. Take action – may or may not need spares/parts – to return asset to its condition prior to the event that prompted the request. Does not necessarily return to original design specs, but the condition immediately prior to which it was withdrawn from service. Generally performed in place. Action does not alter the value of the asset or its depreciation. Example: Pulley belt has broken on an induced draft fan, and the belt needs to be replaced.
Remove	Infrequent action. Remove of obsolete asset. Does not involve repair, does not involve replacement. It is removed from active service, and salvaged/scrapped/removed from an asset accounting perspective. Example: A truck off-loading transfer pump – required with former trucking contractor – now no longer needed as trucks are all pump-equipped to do their own transfer.
Replacement	Frequent action, where the entire asset is removed and replaced with an equal or like asset in terms of asset performance. Conditions are brought up to original performance of the asset. Action does not alter the value of the asset or its depreciation. Example: Remove and replace a 25 HP centrifugal transfer pump.

Calibrate	Moderate frequency, but skilled action. The asset is calibrated and often verified (tested/certified) for accuracy and precision. Often associated with field instrumentation (sensors and valves). A related action is re-calibration or re-ranging to a differing process requirement. Action does not alter the value of the asset or its depreciation. Example: the RTD on tank 225 was re-ranged and calibrated to 0 – 200 degrees F.
Modify/improve	Relatively frequent. Often involving some elements of design, this involves altering the original asset design to improve its usability and performance in operations. This alters its design to make it perform better. Because of this, its asset value has increased by the amount of capital invested to make this improvement. Example: A rigid shaft coupling on a 50 hp centrifugal pump is replaced with a flexible coupler to reduce the frequent bearing and/or seal failures in the original design. A second (simple example) is to replace a failed 20 hp centrifugal pump with a 30 hp centrifugal pump: rather than replace like for like, it is up-graded to higher horsepower. Again, its asset value has increased by the amount of additional capital invested to make this improvement (30 hp vs. 20 hp pump).

6.2.11 Physical asset requirement property

Table 66 defines the attributes for *physical asset requirement property* objects.

Physical asset requirement properties may contain nested physical asset requirement properties.

Table 66 — Attributes of physical asset requirement property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>equipment property</i> or <i>equipment class property</i> for a specific <i>segment requirement</i> .	{not applicable}	Repeatability	{not applicable}	{not applicable}
Description	Contains additional information and descriptions of the <i>equipment requirement property</i> definition.	{not applicable}	Drilling consistency	{not applicable}	{not applicable}
Value	The value, set of values, or range of the associated property. For example: Wet, Dry	{not applicable}	0.0002	{not applicable}	{not applicable}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	{not applicable}	Inches	{not applicable}	{not applicable}
Quantity	Specifies the amount of physical asset property required for the parent physical asset, if applicable.	{not applicable}	{not applicable}	{not applicable}	{not applicable}
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	{not applicable}	{not applicable}	{not applicable}	{not applicable}

6.2.12 Material requirement

An identification of a material that is expected to be used in the operations request shall be presented as a material requirement. Material requirements contain definitions of materials that may be consumed, produced, replaced, sampled, or otherwise used in manufacturing.

Table 67 defines the attributes for *material requirement* objects.

Table 67 — Attributes of material requirement

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Material Class	Identifies the associated <i>material class</i> or set of <i>material classes</i> of the requirement for a specific <i>segment requirement</i> .*	Widgets	Aluminum	Widgets	Bolt
Material Definition	Identifies the associated <i>material definition</i> or set of <i>material definitions</i> of the requirement for a specific <i>segment requirement</i> .*	Export Quality Widgets	Aluminum sheet	Export Quality Widgets	10 mm bolt
Material Lot	Identifies the associated material lot, or set of <i>material lots</i> of the requirement for a specific <i>segment requirement</i> .*	BWLOT-2282	DW94	BWLOT-2282	4823
Material Sublot	Identifies the associated material sublot, or set of <i>material sublots</i> of the requirement for a specific <i>segment requirement</i> .*	BWLOT-2282-A	{not applicable}	{not applicable}	A
Description	Contains additional information and descriptions of the <i>material requirement</i> definition.	Master Segment - Number of Widgets to produce.	Blank sheet to run test on	Material to inspect/test -- selected randomly from production lot	Export quality bolt
Material Use	Identifies the use of the material.	Consumed	Consumed	Inspection	Consumable
Storage Location	Identifies the proposed location of the material, if applicable.	Finished Goods Inventory	Rack 11	Finished Goods Inventory	Warehouse B, Bin 42
Quantity	Specifies the amount of material to be used, if applicable. Applies to each member of the <i>material lot</i> , <i>materials definition</i> , or <i>material class</i> sets.	1500	1	1	4
Quantity Unit of Measure	Identifies the unit of measure of the quantity if applicable.	Units	Sheet	Each	Each
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit. Note 2 If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot, as defined in Part 1 of this standard, not an assembly.	Permanent	Transient	Permanent	Transient

NOTE * Typically either a material class, material definition, material lot, or material subplot is specified.

Defined values for *material use* for production operations shall be: consumable, consumed, produced.

Defined values for *material use* for maintenance operations shall be: consumable, replaced asset, replacement asset

Defined values for quality operations shall be: consumable, sample, returned sample

Defined values for *material use* for inventory operations shall be: consumable, carrier, returned carrier

A material requirement may be defined as containing an assembly of material requirements and as part of an assembly of material requirements:

1. A material requirement may define an assembly of zero or more material requirements.
2. A material requirement may be an assembly element of zero or more material requirements.
3. An assembly may be defined as a permanent or transient assembly of material requirements.
4. An assembly may be defined as physical or a logical assembly of material requirements.

6.2.13 Material requirement property

Properties of the material requirement shall be identified as material requirement properties. Specific elements associated with each material requirement may be included in one or more material requirement properties.

Table 68 defines the attributes for *material requirement property* objects.

Material requirement properties may contain nested material requirement properties.

Table 68 — Attributes of material requirement property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>material property</i> or <i>material class property</i> for a specific <i>segment requirement</i> .	Color	Size	OD	MOC
Description	Contains additional information and descriptions of the <i>material produced requirement property</i> definition.	Specifies the color for this specific operations request., in the polishing segment	Size required by calibration test	Outside diameter	Material of Construction
Value	The value, set of values, or range of the associated property. For example Red, Orange, Yellow, Green, Blue, Indigo, Violet	Red	3 x 5	3.257	304 Stainless
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Feet	Cm	{not applicable}
Quantity	Specifies the amount of material to be produced, if applicable.	100	{not applicable}	{not applicable}	{not applicable}
Quantity Unit of Measure	Identifies the unit of measure of the quantity if applicable.	Units	{not applicable}	{not applicable}	{not applicable}

6.2.14 Requested segment response

The identification of the information sent back as a result of the *production request* is a *requested segment response*. This information is of the same form as a *segment response*, but without actual values. (see the Clause 6.3.4)

A *requested segment response* may include required information, which presents information reported on from production, such as the actual amount of material consumed.

A *requested segment response* may include optional information, which presents information that may be reported on from production, such as operator-entered comments.

6.3 Operations performance information

6.3.1 Operations performance model

Operations performance is a report on requested manufacturing and is a collection of operations responses. Operations responses are responses from manufacturing that are associated with an operations request. There may be one or more Operations responses for a single Operations request if the manufacturing facility needs to split the Operations request into smaller elements.

Figure 15 below is the operations performance model.

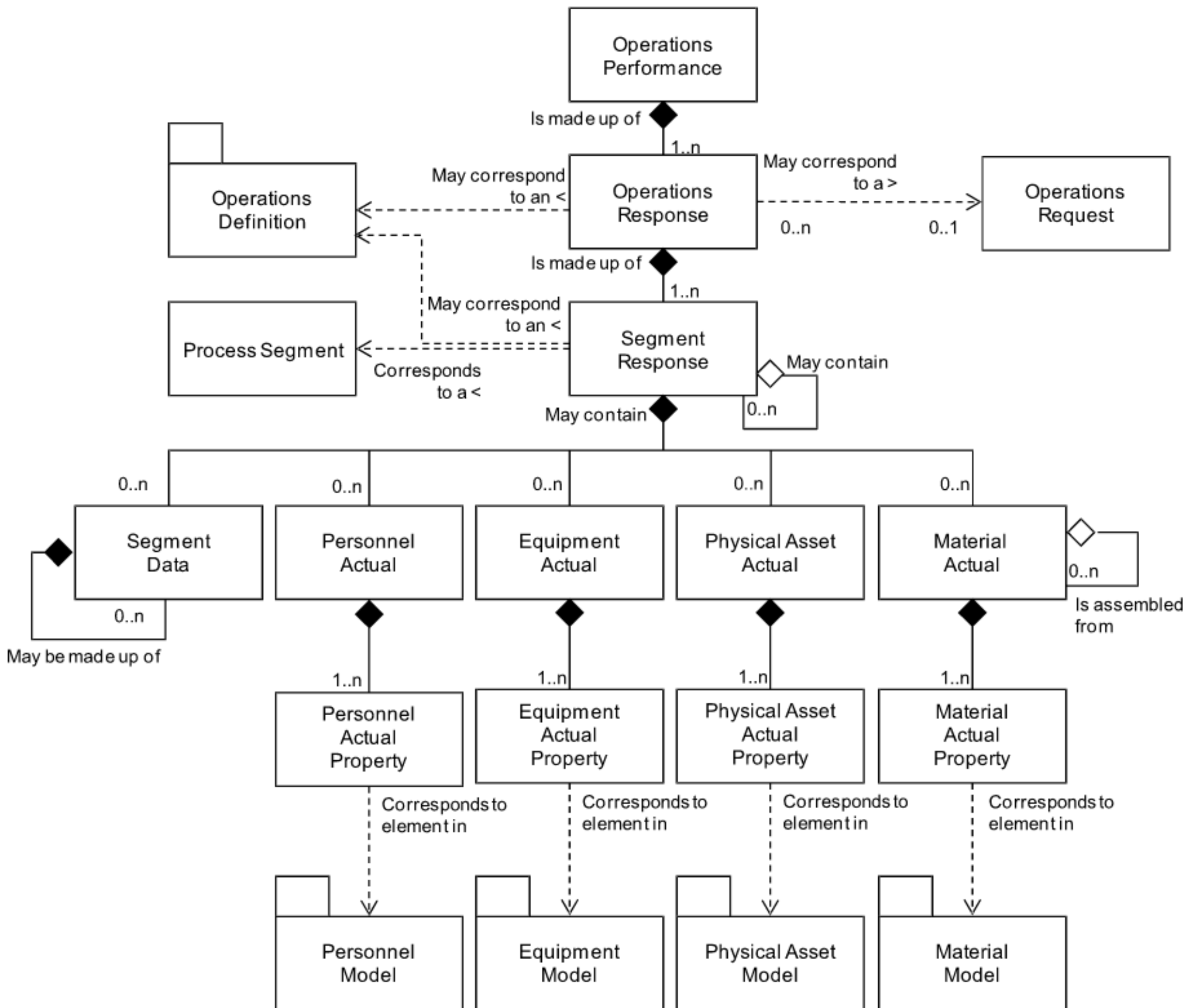


Figure 15 — Operations performance model

6.3.2 Operations performance

The performance of the requested manufacturing requests shall be listed as operations performance. Operations performance shall be a collection of operations responses.

Table 69 defines the attributes for *operations performance* objects.

Table 69 — Attributes of operations performance

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of the <i>operations performance</i> and could include version and revision identification. The ID shall be used in other parts of the model when the <i>operations performance</i> needs to be identified.	1999-10-27-A15	20061027M04	20061027M04	20061027M04
Description	Contains additional information and descriptions of the <i>operations performance</i> .	Operations performance report on Oct 27, 1999 operations schedule.	Maintenance performance message	{not applicable}	{not applicable}
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. "Mixed" shall be used when operations performance contains several categories of operations responses or segment responses.	Production	Maintenance	Quality	Inventory
Operations schedule	An identification of the associated <i>operations schedule</i> , if applicable. <i>Operations performance</i> may not relate to an <i>operations schedule</i> , it may be a report on all operations for a specific time, or reported on by plant floor events.	1999-10-27-A15	MWOIDND	QTEST55	MOVE99
Start Time	The starting time of the associated <i>operations performance</i> , if applicable.	10-28-1999	10-28-2006 2:00 UTC	10-28-2006 2:00 UTC	10-28-2006 2:00 UTC
End Time	The ending time of the associated <i>operations performance</i> , if applicable.	10-30-1999	10-28-2006 2:30 UTC	10-28-2006 2:30 UTC	10-28-2006 2:30 UTC
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	{not applicable}	{not applicable}
Performance State	Indicates the state of the Operations Performance. Possible values are "Ready", "Completed", "Aborted", and "Holding"	Ready	Completed	Holding	Aborted
Published Date	The date and time on which the <i>operations performance</i> was published or generated.	10-27-1999 13:42 EST	10-28-2006 11:00 UTC	10-28-2006 11:00 UTC	10-28-2006 11:00 UTC

6.3.3 Operations response

The responses from manufacturing that are associated with an operations request shall be used as operations responses. There may be one or more operations responses for a single operations request if the manufacturing facility needs to split the operations request into smaller elements.

An operations response may include the status of the request, such as the percentage complete, a finished status, or an aborted status.

Table 70 defines the attributes for *operations response* objects.

Table 70 — Attributes of operations response

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification within the associated <i>operations response</i> . The ID shall be used in other parts of the model when the <i>operations response</i> needs to be identified.	1001091	8490234	E938723	KPP84022
Description	Contains additional information and descriptions of the <i>operations response</i> .	July Actuals	Test program to verify X-Y coordinates within calibration	Verify stock dimensions	Pull part from warehouse, tag, and forward stage
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed. “Mixed” shall be used when operations response contains several categories of segment responses.	Production	Maintenance	Quality	Inventory
Operations request	An identification of the associated <i>operations request</i> , if applicable. <i>Operations response</i> may not relate to an <i>operations request</i> , it may be a report on all operations for a specific time, or reported on by plant floor events.	1001091	59328AC8	E938723	KIT493
Start Time	The starting time of this <i>operations response</i> .	1999-10-27 8:33 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 3:30 UTC
End Time	The ending time of this <i>operations response</i> .	1999-10-27 16:55 UTC	10-28-2006 2:30 UTC	10-28-2006 4:45 UTC	10-28-2006 5:00 UTC
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Operations Definition ID	Identifies the associated <i>Operations definition</i> that was used, if applicable. This may not match the request, if alternate specifications are allowed.	Export Quality Widget V02	CNC Daily Maintenance Procedure	T48340 v1.2	BOM for Export Quality Widget
Response State	Indicates the state of the Operations Response. Possible values are “Ready”, “Completed”, “Aborted”, and “Holding”	Ready	Completed	Holding	Aborted

6.3.4 Segment response

Information on a segment of an operations response shall be used as a segment response. A segment response shall be made up of zero or more sets of information on segment data, personnel actual, equipment actual, and material actual.

A segment response shall include

- a) an identification of the associated process segment;
- b) the actual starting time;
- c) the actual stopping time.

NOTE 1 A response actual may contain information that defines if the response was required or optional when the segment response is used as a requested segment response.

Table 71 defines the attributes for *segment response* objects.

Table 71 — Attributes of segment response

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Uniquely identifies an instance of a <i>process segment</i> executed. NOTE 2 The same process segment may be referenced multiple times in a segment response.	A54-1	KU492-SP	48283-SR	44828377 37883829
Description	Contains additional information and descriptions of the <i>segment response</i> .	Master segment, containing material produced actuals.	Test program to verify X-Y coordinates within calibration	Verify stock dimensions	Pull part from warehouse, tag, and forward stage
Operations type	Describes the category of operations. Required attribute Defined values are: Production, Maintenance, Quality, Inventory, or Mixed.	Production	Maintenance	Quality	Inventory
Process Segment	An identification of the <i>process segment</i> associated with the <i>segment response</i> .	Master Segment	Run X-Y test	RMT38283	Kiting segment
Actual Start Time	The actual start time of this <i>segment response</i> .	1999-10-27 8:33 UTC	10-28-2006 2:00 UTC	10-28-2006 4:00 UTC	10-28-2006 4:00 UTC
Actual End Time	The actual end time of this <i>segment response</i> .	1999-10-27 16:55 UTC	10-28-2006 2:30 UTC	10-28-2006 4:30 UTC	10-28-2006 6:30 UTC
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Operations Definition ID	Identifies the associated <i>Operations definition</i> that was used, if applicable. This may not match the request, if alternate specifications are allowed.	Export Quality Widget V02	CNC Daily Maintenance Procedure	T48340 v1.2	BOM for Export Quality Widget

EXAMPLE There may be multiple segments defined. There may be one master segment = that applies to the entire operations response. The master segment is made up of multiple nested segments for individually reported segments =.

Information that applies across all segments of the operations response, such as a final material produced, may be represented as a material produced in the master segment.

Information that applies to specific segments, such as widget polishing equipment actually used may be reported as part of the polishing segment.

6.3.5 Segment data

Other information related to the actual operations made shall be presented as segment data.

Segment data may contain nested segment data.

Table 72 defines the attributes for *segment data* objects.

Table 72 — Attributes of segment data

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	The identification of the <i>segment data</i> .	Widget Clock Speed	Comment	Thickness	Location
Description	Contains additional information and descriptions of the <i>segment data</i> .	Defines the average measured clock speed of the produced widgets.	Comment entered by maintenance	Actual measurement	Actual location kit was left in
Value	The value or set of values of the <i>segment data</i> .	233	Sheet was nicked in first test. Second sheet was ok.	6	East Wing Manufacturing Line #2
Value Unit of Measure	The engineering units in which the value is defined, if applicable.	MHz	{not applicable}	mm	{not applicable}

6.3.6 Personnel actual

An identification of a personnel capability used during a specified segment shall be used as personnel actual. Operational functions often require people as a resource to carry out tasks.

Personnel actuals shall include the identification of each resource used, usually identifying a specific personnel capability or personnel class, such as end-point transmission assembly operators, or personnel IDs such as Jean Smith or SS# 999-123-4567.

Specific information about personnel actuals shall be listed in personnel actual properties.

NOTE Examples of personnel actual properties are

- the actual duration of use of the personnel during the product segment, such as 2 h; this information is often needed for actual costing analysis;
- actual monitored exposure times by the personnel during the product segment;
- the location of the personnel after use in the product segment, such as area 51; this information is often used for short-term scheduling of personnel resources.

Table 73 defines the attributes for *personnel actual* objects.

Table 73 — Attributes of personnel actual

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Personnel Class	Identifies the associated <i>personnel class</i> or set of <i>personnel classes</i> actually used for a specific <i>segment response</i> .	Widget Polisher	CNC operator	[not applicable]	Warehouse worker
Person	Identifies the associated <i>person</i> or set of <i>persons</i> actually used for a specific <i>segment response</i> . Typically either <i>personnel class</i> or <i>person</i> is specified, but not both.	Gidget	(not applicable)	261343	Sara Feye
Description	Contains additional information and descriptions of the <i>personnel actual</i>	Defines the specific polishing operator used in operations request.	Trained CNC operator	Quality personnel trained in stock inspections	Person to assemble the kit
Personnel Use	Defines the actual use of the personnel class or person.	Allocated	Certified	{not applicable}	{not applicable}
Quantity	Specifies the amount of personnel resources used in the parent segment, if applicable. Applies to each member of the <i>person</i> and <i>personnel class</i> sets.	1	1	1	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Full Time Equivalents	Full Time Equivalents	Full Time Equivalent s	Full Time Equivalent s

6.3.7 Personnel actual property

Table 74 defines the attributes for *personnel actual property* objects.

Personnel actual properties may contain nested personnel actual properties.

Table 74 — Attributes of personnel actual property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>person property</i> or <i>personnel class property</i> for a specific <i>segment response</i> .	Polishing Certification Level	CNC daily maintenance certification	Stock receiving inspection certification	(not applicable)
Description	Contains additional information and descriptions of the <i>personnel actual property</i> definition.	Level of polishing skill certification actually used for the widget polisher	Training level required	Must have current certification	(not applicable)
Value	The value or set of values for the associated property. For example: Apprentice, Journeyman, Master	Master	True	True	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Boolean	Boolean	(not applicable)
Quantity	Specifies the amount of personnel resources used in the parent segment, if applicable.	.25	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Hour	(not applicable)	(not applicable)	(not applicable)

6.3.8 Equipment actual

An identification of an equipment capability used during a specified segment shall be identified as an equipment actual. Operations functions often require equipment as a resource to carry out tasks.

Equipment actual shall include the identification of the equipment used, usually identifying a specific piece of equipment.

Specific information about equipment actuals shall be listed in equipment actual properties.

NOTE Examples of equipment actual properties are

- the actual duration of use of the equipment during the product segment; this information is often needed for actual costing analysis;
- the equipment condition, after use in the product segment, such as a status of available, out-of-service, or cleaning; this information is often used for short-term scheduling of equipment resources;
- the equipment set-up procedures used for the product segment; this information is often needed for actual costing analysis and scheduling feedback;
- other equipment attributes, such as percentage of available capability used.

Table 75 defines the attributes for *equipment actual* objects.

Table 75 — Attributes of equipment actual

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Equipment Class	Identifies the associated <i>equipment class</i> or set of <i>equipment classes</i> actually used for a specific <i>segment response</i> .	Widget Polishing Machine	CNC Drill Press	(not applicable)	(not applicable)
Equipment	Identifies the associated <i>equipment</i> or set of <i>equipment</i> actually used for a specific <i>segment response</i> . Typically either <i>equipment class</i> or <i>equipment</i> is specified, but not both.	WPM-20	DP-1	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the <i>equipment actual</i>	Specifies the actual machine used for this operations request.	Automated drill press	(not applicable)	(not applicable)
Equipment Use	Defines the actual use of the equipment class or equipment.	{not applicable}	{not applicable}	{not applicable}	{not applicable}
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable. Applies to each member of the <i>equipment</i> and <i>equipment class</i> sets.	.05	1	{not applicable}	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours	Machine	{not applicable}	(not applicable)

6.3.9 Equipment actual property

Table 76 defines the attributes for *equipment actual property* objects.

Equipment actual properties may contain nested equipment actual properties.

Table 76 — Attributes of equipment actual property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>equipment property</i> or <i>equipment class property</i> for a specific <i>segment response</i> .	Polisher Type	Holes out of tolerance	{not applicable}	(not applicable)
Description	Contains additional information and descriptions of the <i>equipment actual property</i> definition.	Actual polisher used for this process segment.	Number of drilled hole out of x-y tolerance	{not applicable}	(not applicable)
Value	The value or set of values for the associated property. For example: Wet, Dry.	Dry	0	{not applicable}	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Number of Holes	{not applicable}	(not applicable)
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable	.05	2	{not applicable}	(not applicable)
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours	Tests	{not applicable}	(not applicable)

6.3.10 Physical asset actual

An identification of a physical asset capability used during a specified segment shall be identified as an physical asset actual. Operations functions often require physical asset as a resource to carry out tasks.

Physical asset actual shall include the identification of the physical asset used, usually identifying a specific piece of physical asset.

Specific information about physical asset actuals shall be listed in physical asset actual properties.

Table 77 defines the attributes for *physical asset actual* objects.

Table 77 — Attributes of physical asset actual

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Physical Asset Class	Identifies the associated <i>physical asset class</i> or set of <i>physical asset classes</i> actually used for a specific <i>segment response</i> .	{not applicable}	CNC Drill Press	{not applicable} >	{not applicable}
Physical Asset	Identifies the associated <i>physical asset</i> or set of <i>physical assets</i> actually used for a specific <i>segment response</i> . Typically either <i>physical asset class</i> or <i>physical asset</i> is specified, but not both.	{not applicable}	Serial #: 5563442 Asset ID: 44Q56W	{not applicable}	{not applicable}
Description	Contains additional information and descriptions of the <i>physical asset actual</i>	{not applicable}	Cameroon Drill Press	{not applicable}	{not applicable}
Physical Asset Use	Defines the actual use of the physical asset class or physical asset. Example for maintenance: Repaired, Removed, Replacement, Calibrated, Modified/Improved	{not applicable}	Calibrated	{not applicable}	{not applicable}
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable. Applies to each member of the <i>equipment</i> and <i>equipment class</i> sets.	{not applicable}	1	{not applicable}	{not applicable}
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	{not applicable}	Machine	{not applicable}	{not applicable}

6.3.11 Physical asset actual property

Table 78 defines the attributes for *physical asset actual property* objects.

Physical asset actual properties may contain nested physical asset actual properties.

Table 78 — Attributes of physical asset actual property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>physical asset property</i> or <i>physical asset class property</i> for a specific <i>segment response</i> .	Polisher Type	Repeatability	{not applicable}	{not applicable}
Description	Contains additional information and descriptions of the <i>physical asset actual property</i> definition.	Actual polisher used for this process segment.	Drilling consistency	{not applicable}	{not applicable}
Value	The value or set of values for the associated property. For example: Wet, Dry.	Dry	.0002	{not applicable}	{not applicable}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Inches	{not applicable}	{not applicable}
Quantity	Specifies the amount of physical asset resources used in parent segment, if applicable	.05	2	{not applicable}	{not applicable}
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours	Tests	{not applicable}	{not applicable}

6.3.12 Material actual

An identification of a material that was used in the operations request shall be presented as a material actual. Material actual contain definitions of materials that may have be consumed, produced, replaced, sampled, or otherwise used in manufacturing.

Table 79 defines the attributes for *material actual* objects.

Table 79 — Attributes of material actual

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Material Class	Identifies the associated <i>material class</i> or set of <i>material classes</i> actually made for a specific <i>segment response</i> .*	Widgets	Aluminum	{not applicable}	Bolt
Material Definition	Identifies the associated <i>material definition</i> or set of <i>material definitions</i> actually made for a specific <i>segment response</i> .*	Export Quality Widgets	Aluminum sheet	{not applicable}	10 mm bolt
Material Lot	Identifies the associated <i>material lot</i> or set of <i>material lots</i> actually made for a specific <i>segment response</i> .*	BWLOT-2282	DW94	{not applicable}	4857
Material Sublot	Identifies the associated <i>material sublot</i> or set of <i>material sublots</i> actually made for a specific <i>segment response</i> .*	BWLOT-2282-A	DW94-3	{not applicable}	4857F
Description	Contains additional information and descriptions of the <i>material produced actual</i> .	Master Segment - Number of Widgets actually produced.	Blank sheet to run test on	{not applicable}	Export quality bolt
Material Use	Identifies the use of the material. Defined values for production operations are: Consumable, Consumed, Produced. Defined values for maintenance operations are: Consumable, Replaced Asset, Replacement Asset Defined values for quality operations are: Consumable, Sample, Returned Sample Defined values for inventory operations are: Consumable, Carrier, Returned Carrier	Produced	Consumed	{not applicable}	Consumed
Storage Location	Identifies the actual location of the produced material, if applicable.	Finished Goods Inventory	Rack 11	{not applicable}	Warehouse B, Bin 42
Quantity	Specifies the amount of material produced by the parent segment. Applies to each member of the <i>material lot</i> , <i>materials definition</i> , or <i>material class</i> sets.	1498	2	{not applicable}	4
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Units	Sheet	{not applicable}	Each

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

NOTE * Typically either a material class, material definition, material lot, or material subplot is specified.

A material actual may be defined as containing an assembly of material actuals and as part of an assembly of material actuals:

1. A material actual may define an assembly of zero or more material actuals.
2. A material actual may be an assembly element of zero or more material actuals.
3. An assembly may be defined as a permanent or transient assembly of material actuals.
4. An assembly may be defined as physical or a logical assembly of material actuals.

6.3.13 Material actual property

Table 80 defines the attributes for *material actual property* objects.

Material actual properties may contain nested material actual properties.

Table 80 — Attributes of material actual property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of the associated <i>material property</i> or <i>material class property</i> for a specific <i>segment response</i> .	Color	Size	{not applicable}	MOC
Description	Contains additional information and descriptions of the <i>material produced actual property</i> definition.	Defines the color actually produced, in the polishing segment	Size required by calibration test	{not applicable}	Material of Construction
Value	The value or set of values for the associated property. For example: Red, Orange, Yellow, Green, Blue, Indigo, Violet.	Red	3 x 5	{not applicable}	316 Stainless
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Color	Feet	{not applicable}	{not applicable}
Quantity	Specifies the amount of material produced by the parent segment. Applies to each member of the <i>material lot</i> , <i>materials definition</i> , or <i>material class</i> sets.	1002	{not applicable}	{not applicable}	{not applicable}
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Units	{not applicable}	{not applicable}	{not applicable}

6.4 Operations capability information

6.4.1 Operations capability model

Operations capability information is the collection of information about all resources for operations for selected future and past times. This is made up of information about equipment, material, personnel, and process segments. Operations capability describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

Operations capability is defined as a collection of personnel capabilities, equipment capabilities, material capabilities, and process segment capabilities, for a given slice of time (past, current, or future), and defined as committed, available, and unattainable.

Figure 16 is the operations capability model that applies to production, maintenance, quality test and inventory.

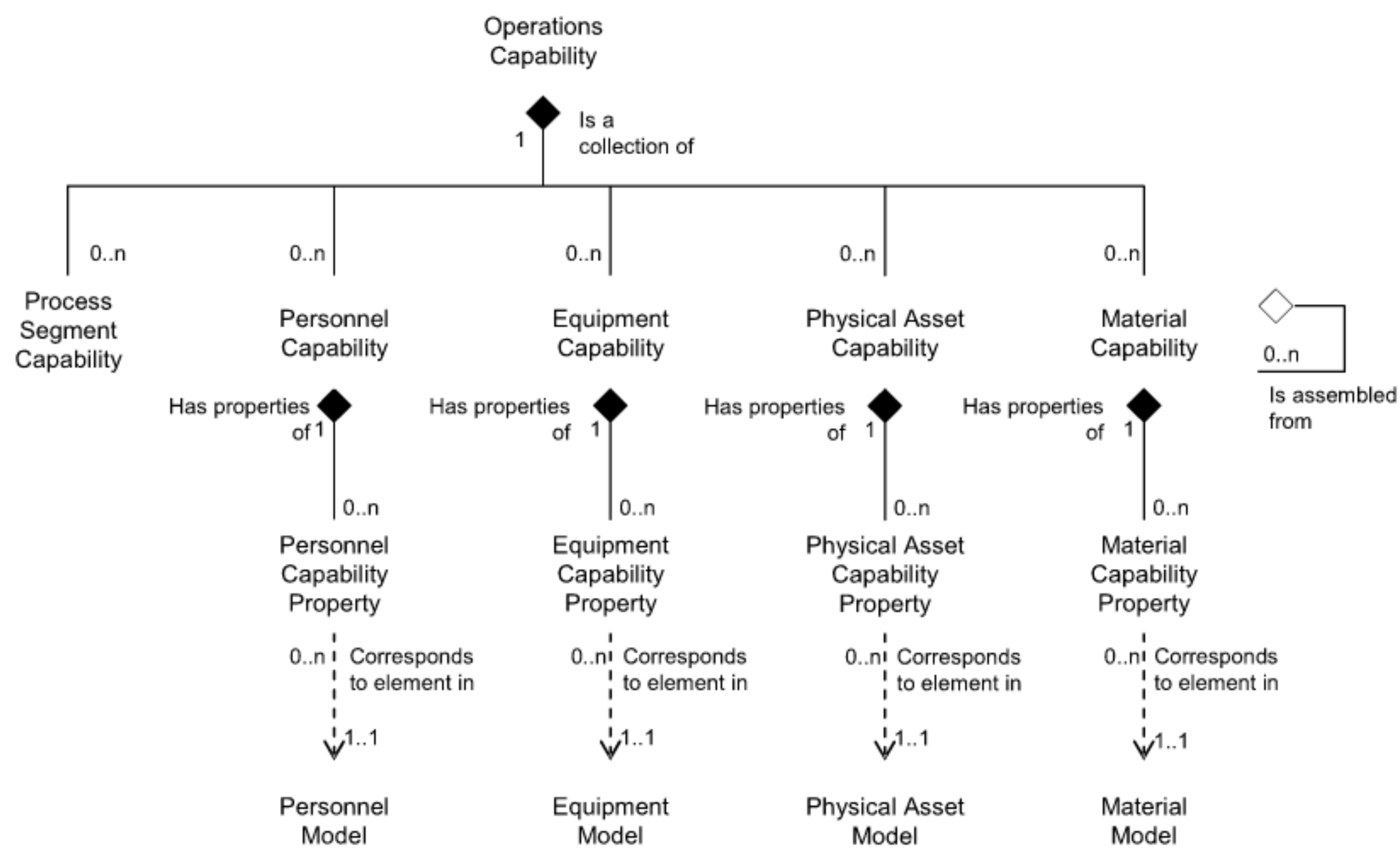


Figure 16 — Operations capability Model

6.4.2 Operations capability

Table 81 defines the attributes for *operations capability* objects.

Table 81 — Attributes of operations capability

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Defines a unique instance of an operations capability for a specified element of the equipment hierarchy model [Part 1 Clause 5.2] (<i>enterprise, site, area, work center, or work unit</i>).	1999/12/30-HPC52	84818343DF	4737845	EDIDCUIUE
Description	Contains additional information and descriptions of the <i>operations capability</i> definition.	One day's operations capacity for the Boston Widget Company.	Maintenance capability for one week	Test incoming material	Warehouse kit prep
Capacity Type	The capacity type: Used, Unused, Total, Available, Unattainable, or Committed.	Available	Committed	Available	Unattainable
Reason	Defines the reason for the capability type. Example 1: If committed, then committed for production or for maintenance, or if unavailable, then the reason for the unavailability. Example 2: If unused capacity, then the reason for the capacity was unused, such as a specific equipment failure or unacceptable product quality	Available for Work	Scheduled calibration	Available for inspections	Down for inventory cycle count
Confidence Factor	A measure of the confidence of the capacity value. Example 3: A percentage value representing the confidence of the capacity	90%	100%	Medium	2
Start Time	The starting date and time of the operations capability.	1999-12-29 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	10-28-2006 00:00 UTC
End Time	The ending date and time of the operations capability.	1999-12-30 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	10-29-2006 00:00 UTC
Published Date	The date and time on which the <i>operations capability</i> was published or generated.	1999-11-03 13:55	10-25-2006 00:00 UTC	10-25-2006 00:00 UTC	10-25-2006 00:00 UTC
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. Zero or more as required to identify the specific scope of the operations capability definition.	Boston Widget Company	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B

6.4.3 Personnel capability

A representation of the capability of persons or personnel classes that is committed, available, or unattainable for a defined time shall be known as a personnel capability. Personnel capability may contain references to either persons or personnel classes.

Personnel capability shall identify

- a) the availability (available, unattainable, committed, used, unused, total);
- b) the time associated with the availability (for example, third shift on a specific date).

Specific personnel capabilities shall be presented in personnel capability properties. The personnel capability property may include the quantity of the resource referenced.

NOTE For example, 3 horizontal drill press operators available for the third shift on 2000-02-29.

Table 82 defines the attributes for *personnel capability* objects.

Table 82 — Attributes of personnel capability

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Personnel Class	Identifies the associated <i>personnel class</i> of the capability.	Widget Assembly Machine Operator	CNC operator	Quality Assurance Tech	(not applicable)
Person	Identifies the associated <i>person</i> of the capability.	SSN 999-55-1212	Charlie Goode	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the <i>personnel capability</i> definition.	Widget machine operator availability over the 2000 New Year boundary	Trained CNC operator	Quality personnel trained in stock inspections	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Available	Committed	Available	(not applicable)
Reason	Defines the reason for the capability type.	Available for Work	Scheduled calibration	Available for incoming inspections	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90%	100%	100%	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent <i>operations capability</i> hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	South Shore Work Plant	CNC Machine Asset ID 13465	Test Cell 4 Receiving	(not applicable)
Personnel Use	Defines the expected capability use of the personnel class or person.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Start Time	The starting time associated with the <i>personnel capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	(not applicable)
End Time	The ending time associated with the <i>personnel capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	(not applicable)
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	48	1	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours	Full Time Equivalent	Full Time Equivalent	(not applicable)

Where *persons* are members of multiple *personnel classes* then the *personnel capability* information defined by *personnel class* should be used carefully because of possible double counts, and personnel resources should be managed at the instance level.

6.4.4 Personnel capability property

Table 83 defines the attributes for *personnel capability property* objects.

Personnel capability properties may contain nested personnel capability properties.

Table 83 — Attributes of personnel capability property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>person property</i> or <i>personnel class property</i> .	Packing Machine Certified	CNC daily maintenance certification	Stock receiving inspection certification	(not applicable)
Description	Contains additional information and descriptions of the <i>personnel capability property</i> definition.	Level of packing machine operator certification	Training level required	Must have current certification	(not applicable)
Value	The value, set of values, or range of the property.	Journeyman	True	True	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	(not applicable)	Boolean	Boolean	(not applicable)
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	16	(not applicable)	(not applicable)	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours	(not applicable)	(not applicable)	(not applicable)

6.4.5 Equipment capability

A representation of the capability of equipment or equipment classes that is committed, available, or unattainable for a specific time shall be used as an equipment capability. Equipment capability may contain references to either equipment or equipment classes.

Equipment capability shall identify

- a) the availability (available, unattainable, committed, used, unused, total);
- b) the time associated with the availability (for example, third shift on a specific date).

Specific equipment capabilities shall be used in equipment capability properties. The equipment capability properties may include the quantity of the resource referenced.

NOTE For example, 3 horizontal drill presses currently available.

Table 84 defines the attributes for *equipment capability* objects.

Table 84 — Attributes of equipment capability

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Equipment Class	Identifies the associated <i>equipment class</i> of the capability.	Widget Lathe	CNC Drill Press	Micrometer	(not applicable)
Equipment	Identifies the associated <i>equipment</i> of the capability.	Lathe machine 15	DP-1	(not applicable)	(not applicable)
Description	Contains additional information and descriptions of the <i>equipment capability</i> definition.	Widget Lathe availability over the 2000 New Year boundary	Automated drill press	Measurement tool	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Unattainable	Committed	Available	(not applicable)
Reason	Defines the reason for the capability type.	Due to Y2K Non compliance	Schedule calibration	Available for measurement	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90%	100%	100%	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent <i>operations capability</i> hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	South Shore Work Plant	CNC Machine Asset ID 13465	Test Cell 4 Receiving	(not applicable)
Equipment Use	Defines the expected capability use of the equipment class or equipment.	(not applicable)	(not applicable)	(not applicable)	(not applicable)
Start Time	The starting time associated with the <i>equipment capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	(not applicable)
End Time	The ending time associated with the <i>equipment capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	(not applicable)
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	48	1	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours	Machine	Tool	(not applicable)

Where *equipment* are members of multiple *equipment classes* then the *equipment capability* information defined by *equipment class* should be used carefully because of possible double counts, and equipment resources should be managed at the instance level.

6.4.6 Equipment capability property

Table 85 defines the attributes for *equipment capability property* objects.

Equipment capability properties may contain nested equipment capability properties.

Table 85 — Attributes of equipment capability property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>equipment property</i> or <i>equipment class property</i> .	Volume	Spindle run-out	Scale definition	(not applicable)
Description	Contains additional information and descriptions of the <i>equipment capability property</i> definition.	Measure of the equipment volume.	Max allowed spindle run-out	Units of measure	(not applicable)
Value	The value, set of values, or range of the property.	10000	less than 0.00008	Metric	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Liters	Inches	{not applicable}	(not applicable)
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	12	{not applicable}	1	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours	{not applicable}	Each	(not applicable)

6.4.7 Physical asset capability

A representation of the capability of a physical asset of class of physical assets (physical asset class) that is committed, available, or unattainable for a specific time shall be used as an physical asset capability. Physical asset capability may contain references to either physical asset or physical asset class.

Physical asset capability shall identify

- c) the availability (available, unattainable, committed, used, unused, total);
- d) the time associated with the availability (for example, third shift on a specific date).

Specific physical asset capabilities shall be used in physical asset capability properties. The physical asset capability properties may include the quantity of the resource referenced.

Table 86 defines the attributes for *physical asset capability* objects.

Table 86 — Attributes of physical asset capability

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Physical Asset Class	Identifies the associated <i>physical asset class</i> of the capability.	Jones Model 23 Lathe	Model 105, XYZ Corp, CNC Drill Press	{not applicable}	(not applicable)
Physical Asset	Identifies the associated <i>physical asset</i> of the capability.	Machine #99298	Serial #: 5563442 Asset ID: 44Q56W	{not applicable}	(not applicable)
Description	Contains additional information and descriptions of the <i>physical asset capability</i> definition.	Widget Lathe availability over the 2000 New Year boundary	Cameroon Drill Press	{not applicable}	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Unattainable	Committed	{not applicable}	(not applicable)
Reason	Defines the reason for the capability type.	Due to Y2K Non compliance	Scheduled calibration	{not applicable}	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90%	100%	{not applicable}	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent <i>operations capability</i> hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	South Shore Work Plant	CNC Machine Asset ID 13465	{not applicable}	(not applicable)
Physical Asset Use	Defines the expected capability use of the physical asset class or physical asset.	{not applicable}	{not applicable}	{not applicable}	(not applicable)
Start Time	The starting time associated with the <i>physical asset capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	{not applicable}	(not applicable)
End Time	The ending time associated with the <i>physical asset capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	{not applicable}	(not applicable)
Quantity	Specifies the quantity of the physical asset capability defined, if applicable.	48	1	{not applicable}	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours	Machine	{not applicable}	(not applicable)

6.4.8 Physical asset capability property

Table 85 defines the attributes for *physical asset capability property* objects.

Physical asset capability properties may contain nested physical asset capability properties.

Table 87 — Attributes of physical asset capability property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>physical asset property</i> or <i>physical asset class</i> .	Volume	Repeatability	{not applicable}	(not applicable)
Description	Contains additional information and descriptions of the <i>physical asset capability property</i> definition.	Measure of the equipment volume.	Drilling consistency	{not applicable}	(not applicable)
Value	The value, set of values, or range of the property.	10000	0.0002	{not applicable}	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Liters	Inches	{not applicable}	(not applicable)
Quantity	Specifies the quantity of the physical asset capability defined, if applicable.	12	{not applicable}	{not applicable}	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours	{not applicable}	{not applicable}	(not applicable)

6.4.9 Material capability

A representation of the capability of material that is committed, available, or unattainable for a specific time shall be used as a material capability. Material capability is used for material lots or sublots. This includes information that is associated with the functions of material and energy control and product inventory control. The currently available and committed material capability is the inventory. WIP (work in progress) is a material capability currently under the control of production.

Material capability shall identify

- a) the availability (available, unattainable, committed, used, unused, total);
- b) the time associated with the availability (for example, third shift on a specific date).

Specific material capabilities shall be listed in material capability properties. The material capability properties may include the quantity of the material referenced.

NOTE For example, 3 sublots in building 3 of material starch lot #12345 committed to production for 2000-02-29.

Table 88 defines the attributes for *material capability* objects.

Table 88 — Attributes of material capability

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Material Class	Identifies the associated <i>material class</i> of the capability.*	Lubricant Oil	Aluminum	{not applicable}	(not applicable)
Material Definition	Identifies the associated <i>material definition</i> of the capability.*	Lube Oil 8999	Aluminum sheet	{not applicable}	(not applicable)
Material Lot	Identifies the associated <i>material lot</i> of the capability.*	8999LU-5G	DW94	{not applicable}	(not applicable)
Material Sublot	Identifies the associated <i>material sublot</i> of the capability.*	8999LU-5G-SL15	{not applicable}	{not applicable}	(not applicable)
Description	Contains additional information and descriptions of the <i>material capability</i> definition.	Lubricant oil commitment over the 2000 New Year boundary	Blank sheet to run test on	{not applicable}	(not applicable)
Capability Type	The capability type: Used, Unused, Total, Available, Unattainable, or Committed.	Committed	Committed	{not applicable}	(not applicable)
Reason	Defines the reason for the capability type.	Available for Work	Scheduled calibration	{not applicable}	(not applicable)
Confidence Factor	A measure of the confidence of the capacity value.	90%	100%	{not applicable}	(not applicable)
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent <i>operations capability</i> hierarchy scope. Zero or more as required to identify the specific scope of the operations capability definition.	Work Line 15	CNC Machine Asset ID 13465	{not applicable}	(not applicable)
Material Use	Defines the expected capability use of the material. For example, Consumed, Produced, or Consumable	Consumed	Committed	{not applicable}	(not applicable)
Start Time	The starting time associated with the <i>material capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	{not applicable}	(not applicable)
End Time	The ending time associated with the <i>material capability</i> . If omitted, then the capability is associated to the parent <i>operations capability</i> end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	{not applicable}	(not applicable)
Quantity	Specifies the quantity of the material capability defined, if applicable.	155	1	{not applicable}	(not applicable)
Quantity Unit of Measure	The unit of measure of the material quantity, if applicable.	Liters	Sheet	{not applicable}	(not applicable)

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
Assembly Type	Optional: Defines the type of the assembly. The defined types are: Physical – The components of the assembly are physically connected or in the same area. Logical – The components of the assembly are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Physical
Assembly Relationship	Optional: Defines the type of the relationships. The defined types are: Permanent – An assembly that is not intended to be split during the production process. Transient – A temporary assembly using during production, such as a pallet of different materials or a batch kit.	Permanent	Transient	Permanent	Transient

NOTE 1 * Typically either a material class, material definition, material lot, or material subplot is specified.

Where *materials* are members of multiple *material classes* then the *material capability* information defined by *material class* should be used carefully because of possible double counts, and material resources should be managed at the instance level.

A material Capability may be defined as containing an assembly of material capabilities and as part of an assembly of material capabilities:

1. A material capability may define an assembly of zero or more material capabilities.
2. A material capability may be an assembly element of zero or more material capabilities.
3. An assembly may be defined as a permanent or transient assembly of material capabilities.
4. An assembly may be defined as physical or a logical assembly of material capabilities.

6.4.10 Material capability property

Table 89 defines the attributes for *material capability property* objects.

Material capability properties may contain nested material capability properties.

Table 89 — Attributes of material capability property

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	An identification of a property of the associated <i>material property</i> or <i>equipment class property</i> .	pH	Size	{not applicable}	(not applicable)
Description	Contains additional information and descriptions of the <i>material capability property</i> definition.	pH of active ingredient	Size required by calibration test	{not applicable}	(not applicable)
Value	The value, set of values, or range of the property.	6.3	3 x 5	{not applicable}	(not applicable)
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	pH	Feet	{not applicable}	(not applicable)
Quantity	Specifies the quantity of the material capability defined, if applicable.	2567	{not applicable}	{not applicable}	(not applicable)
Quantity Unit of Measure	The unit of measure of the associated quantity.	KiloLiters	{not applicable}	{not applicable}	(not applicable)

6.5 Process segment capability information

6.5.1 Process segment capability model

A process segment capability is a representation of a logical grouping of personnel resources, equipment resources, and material that is committed, available, or unavailable for a defined process segment for a specific time.

A representation of a logical grouping of personnel resources, equipment resources, and material that is committed, available, or unavailable for a given process segment for a specific time shall be used as a process segment capability, as shown in Figure 17.

A process segment capability is related to a process segment that can occur during operations.

Process segment capability shall identify

- a) the capability type (available, unattainable, committed, used, unused, total);
- b) the time associated with the capability (for example, third shift on a specific date).

Process segment capabilities shall be made up of

- c) personnel segment capabilities, which lists specific properties required in personnel segment capability properties;
- d) equipment segment capabilities, which lists specific properties required in equipment capability properties;
- e) material segment capabilities, which lists specific properties required in material segment capability properties.

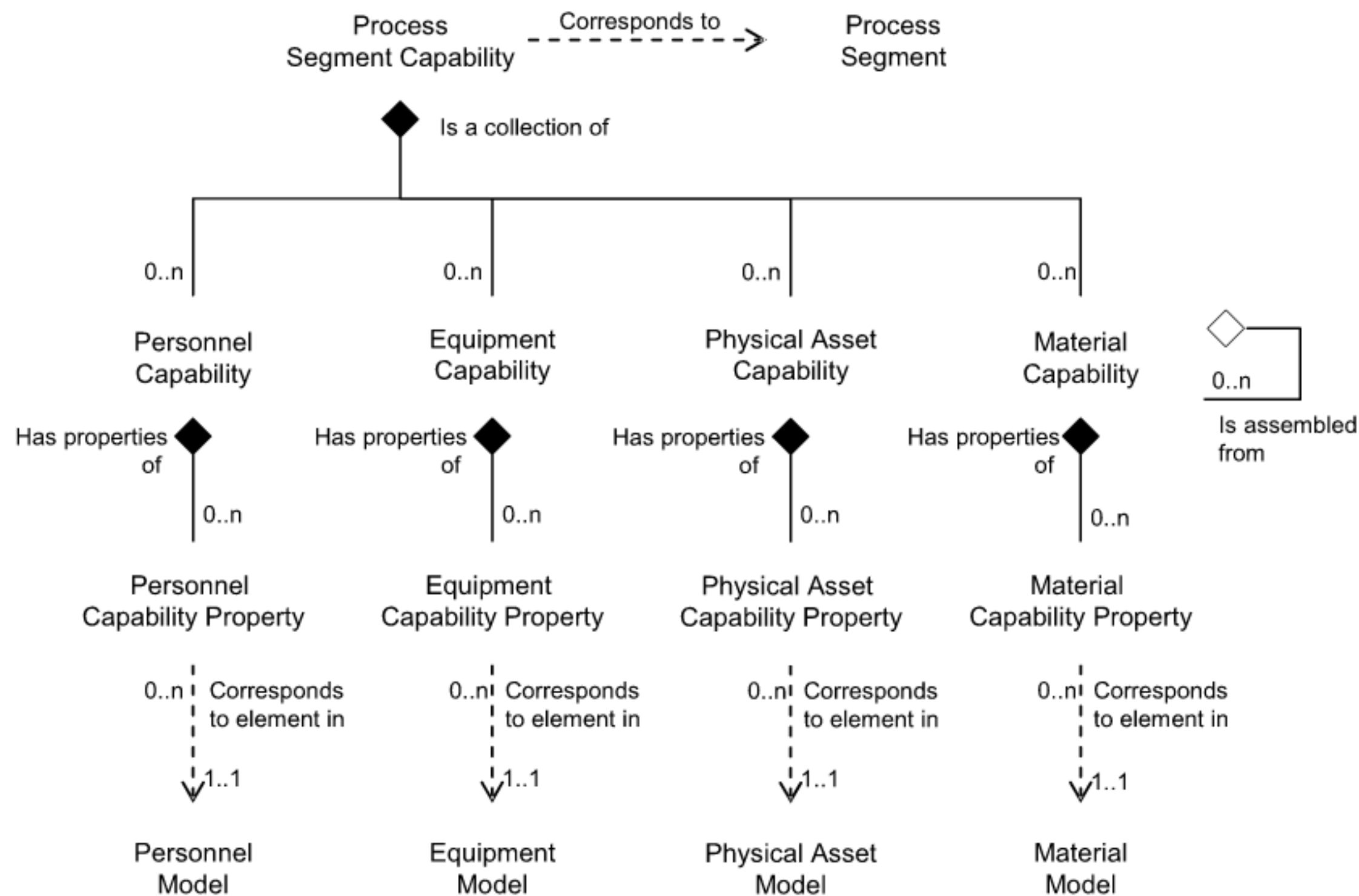


Figure 17 — Process segment capability object model

6.5.2 Process segment capability

Table 90 lists the attributes of *process segment capability*. *Process segment capability* has an equivalent structure to the personnel, equipment and material structure of *operations capability*, except the *process segment capability* is defined for a specific *process segment*.

Table 90 — Attributes of process segment capability

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	Defines a unique instance of a process segment capability for a specified element of the equipment hierarchy model [Part 1 Clause 5.2] (<i>enterprise, site, area, work center, or work unit</i>).	1999/12/30-HPC52	84818343DF	4737845	EDIDCUIUE
Description	Contains additional information and descriptions of the <i>process segment capability</i> definition.	Defines the available capability for the Widget Assembly process segment	Calibration of CNC Drill Press	Incoming aluminum sheet thickness test	Kiting segment
Process Segment	Identifies the <i>process segment</i> .	Widget Assembly	Run X-Y test	RMT38283	Kiting segment
Capacity Type	The capacity type: Available, Unattainable, or Committed.	Available	Committed	Available	Unattainable
Reason	Gives the reason for the capacity type.	Available for Production	Scheduled calibration	Available for incoming inspection	Down for inventory cycle count
Hierarchy Scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent <i>process segment capability</i> hierarchy scope. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Start Time	The starting time of the time span defining the capacity type. If omitted, then the capability is associated to the parent <i>process segment capability</i> start time.	1999-12-30 11:59	10-28-2006 2:00 UTC	10-28-2006 00:00 UTC	10-28-2006 00:00 UTC
End Time	The ending time of the time span defining the capacity type. If omitted, then the capability is associated to the parent <i>process segment capability</i> end time.	2000-01-01 12:00	10-28-2006 2:15 UTC	10-28-2006 8:00 UTC	10-29-2006 00:00 UTC

Process segment capabilities should be used carefully because of possible double counts of resources.

EXAMPLE A resource may be shown as available in multiple *process segments*, but in actual fact may be available for use in only a single *process segment*.

7 Object model inter-relationships

Figure 18 provides an informative illustration of how the object models inter-relate. The operations information presents what was made and what was used. Its elements correspond to information in operations scheduling that listed what to make and what to use. The operations

scheduling elements correspond to information in the operations definition. The operations definition elements correspond to information in the process segment descriptions that present what can be performed with the resources. The operations capability contains what capacities exist for specified resources and for specific process segments for specific periods of time.

The slanted rectangles in Figure 18 represent any of the resources (personnel, equipment, or material) or properties of the resources.

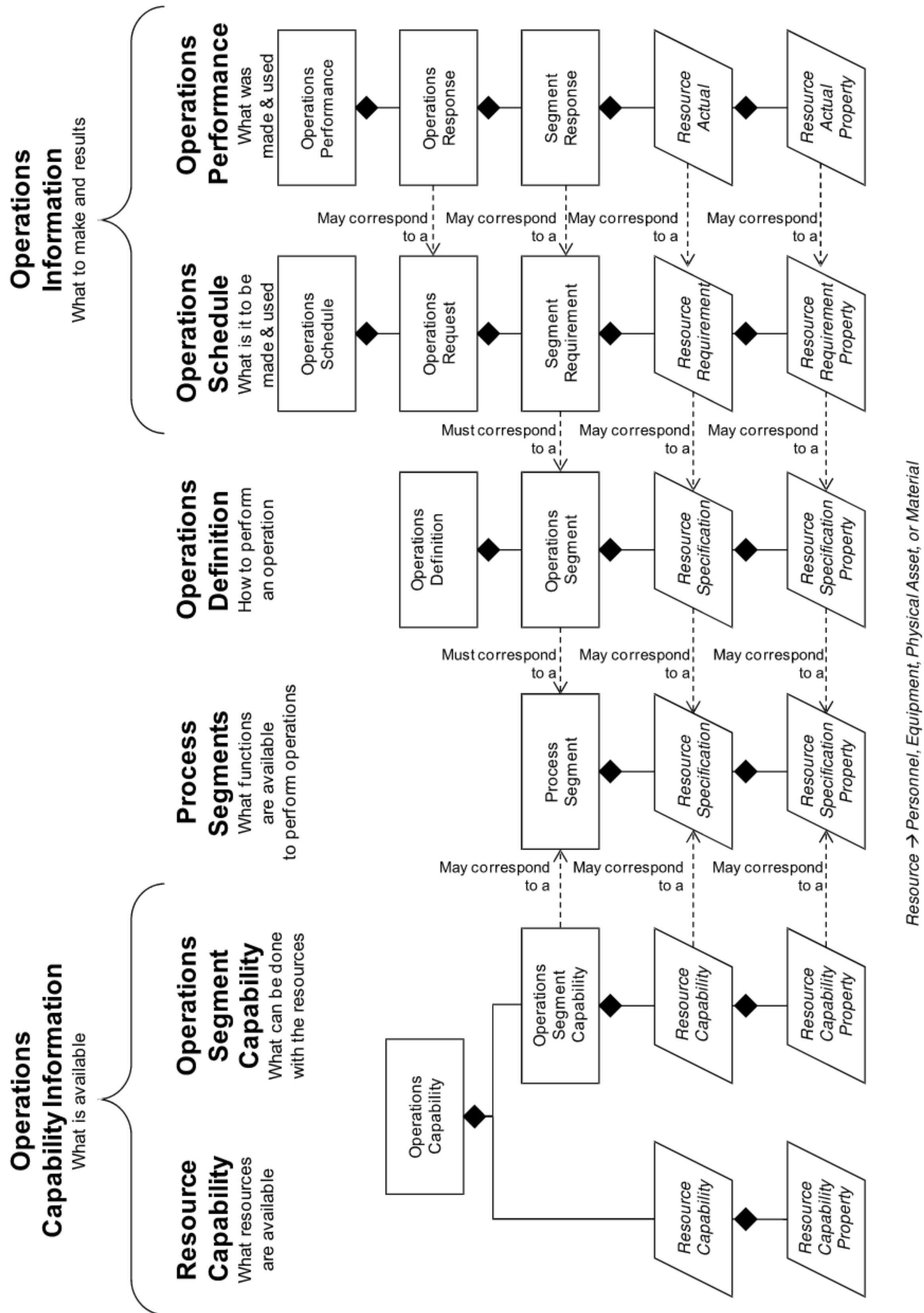


Figure 18 — Object model inter-relationships

NOTE Both resource capability properties and operation segment's operations specifications/properties map their properties to the process segment's resource specification/ properties. They may be subsets of the process segment's resource specification /properties where capability properties are used to evaluate availability and product segment properties may be used to determine requirement specifics for scheduling.

Table 91 provides a cross-reference between the elements of the information flows in the data flow model and the corresponding clause describing the object model.

Table 91 — Model cross-reference

Part 1 Data flow model information	Part 1 - From function	Part 1 - To function	Part 2 - Object model clause
6.5.2 Schedule	Production scheduling (2.0)	Production control (3.0)	6.2 and A.2
6.5.3 Production from plan	Production control (3.0)	Production scheduling (2.0)	6.3 and A.3
6.5.4 Production capability	Production control (3.0)	Production scheduling (2.0)	6.4 and A.4
6.5.5 Material and energy order requirements	Material and energy control (4.0)	Procurement (5.0)	Described in terms of the material model, 5.4.
6.5.6 Incoming order confirmation	Material and energy control (4.0)	Procurement (5.0)	Described in terms of the material model, 5.4.
6.5.7 Long-term material and energy requirements	Production scheduling (2.0)	Material and energy control (4.0)	Described in terms of the material model, 5.4.
6.5.8 Short-term material and energy requirements	Production control (3.0)	Material and energy control (4.0)	Described in terms of the material model, 5.4.
6.5.9 Material and energy inventory	Material and energy control (4.0)	Production control (3.0)	Described in terms of the material model, 5.4.
6.5.10 Production cost objectives	Product cost accounting (8.0)	Production control (3.0)	6.2 and A.2
6.5.11 Production performance and costs	Production control (3.0)	Product cost accounting (8.0)	6.3 and A.3
6.5.12 Incoming material and energy receipt	Material and energy control (4.0)	Product cost accounting (8.0)	<Not detailed in object model>
6.5.13 Quality assurance results	Quality assurance (6.0)	Production control (3.0)	5.4 and 6.3
6.5.14 Standards and customer requirements	Marketing and sales	Quality assurance (6.0)	6.1 and A.1
	Quality assurance (6.0)	Production control (3.0)	
6.5.15 Product and process requirements	Research, development, and engineering	Quality assurance (6.0)	6.1 and A.1
6.5.16 Finished goods waiver	Order processing (1.0)	Quality assurance (6.0)	<Not detailed in object model> Typically unstructured information handled on an <i>ad hoc</i> basis
6.5.17 In-process waiver request	Production control (3.0)	Quality assurance (6.0)	Described in terms of the material model, 5.4.

Part 1 Data flow model information	Part 1 - From function	Part 1 - To function	Part 2 - Object model clause
6.5.18 Finished goods inventory	Product inventory control (7.0)	Production scheduling (2.0)	Described in terms of the material model, 5.4.
6.5.19 Process data	Production control (3.0)	Quality assurance (6.0)	6.3 and A.3
6.5.20 Pack-out schedule	Production scheduling (2.0)	Product inventory control (7.0)	6.2 and A.2
6.5.21 Product and process know-how	Research, development, and engineering	Production control (3.0)	<Not detailed in object model>
6.5.22 Product and process information request	Production control (3.0)	Research, development, and engineering	<Not detailed in object model>
6.5.23 Maintenance requests	Production control (3.0)	Maintenance management (10.0)	6.2
6.5.24 Maintenance responses	Maintenance management (10.0)	Production control (3.0)	6.3
6.5.25 Maintenance standards and methods	Production control (3.0)	Maintenance management (10.0)	<Not detailed in object model>
6.5.26 Maintenance technical feedback	Maintenance management (10.0)	Production control (3.0)	<Not detailed in object model>
6.5.27 Product and process technical feedback	Production control (3.0)	Research, development, and engineering	<Not detailed in object model>
6.5.28 Maintenance purchase order requirements	Maintenance management (10.0)	Procurement (5.0)	<Not detailed in object model>
6.5.29 Production order	Order processing (1.0)	Production scheduling (2.0)	<Not detailed in object model>
6.5.30 Availability	Production scheduling (2.0)	Order processing (1.0)	<Not detailed in object model>
6.5.31 Release to ship	Product shipping administration (9.0)	Product inventory control (7.0)	<Not detailed in object model>
6.5.32 Confirm to ship	Product inventory control (7.0)	Product shipping administration (9.0)	<Not detailed in object model>

8 List of objects

The following tables present a complete list of the objects discussed in this standard.

Table 92 — Common resource objects

Object	Model
personnel class	Personnel Model
personnel class property	Personnel Model
person	Personnel Model
person property	Personnel Model
qualification test specification	Personnel Model
qualification test result	Personnel Model
equipment class	Equipment Model
equipment class property	Equipment Model
equipment	Equipment Model
equipment property	Equipment Model
equipment capability test specification	Equipment Model
equipment capability test result	Equipment Model
physical asset	Physical Asset Model
physical asset property	Physical Asset Model
physical asset class	Physical Asset Model
physical asset class property	Physical Asset Model
physical asset capability test specification	Physical Asset Model
physical asset capability test result	Physical Asset Model
equipment asset mapping	Physical Asset Model
material class	Material Model
material class property	Material Model
material definition	Material Model
material definition property	Material Model
material lot	Material Model
material lot property	Material Model
material subplot	Material Model
material test specification	Material Model
material test result	Material Model
material assembly	Material Model
material definition assembly	Material Model
material class assembly	Material Model
process segment	Process Segment Model
process segment parameter	Process Segment Model
personnel segment specification	Process Segment Model
personnel segment specification property	Process Segment Model
equipment segment specification	Process Segment Model

Object	Model
equipment segment specification property	Process Segment Model
material segment specification	Process Segment Model
material segment specification property	Process Segment Model
material segment specification assembly	Process Segment Model
process segment dependency	Process Segment Model
operations definition	Operations Definition Model
operations material bill	Operations Definition Model
operations segment	Operations Definition Model
parameter specification	Operations Definition Model
personnel specification	Operations Definition Model
personnel specification property	Operations Definition Model
equipment specification	Operations Definition Model
equipment specification property	Operations Definition Model
physical asset specification	Operations Definition Model
physical asset specification property	Operations Definition Model
material specification	Operations Definition Model
material specification property	Operations Definition Model
material specification assembly	Operations Definition Model
operations segment dependency	Operations Definition Model
operations schedule	Operations Schedule Model
operations request	Operations Schedule Model
requested segment response	Operations Schedule Model
segment requirement	Operations Schedule Model
segment parameter	Operations Schedule Model
personnel requirement	Operations Schedule Model
personnel requirement property	Operations Schedule Model
equipment requirement	Operations Schedule Model
equipment requirement property	Operations Schedule Model
physical asset requirement	Operations Schedule Model
physical asset requirement property	Operations Schedule Model
material requirement	Operations Schedule Model
material requirement property	Operations Schedule Model
material requirement assembly	Operations Schedule Model
operations performance	Operations Performance Model
operations response	Operations Performance Model
segment response	Operations Performance Model
segment data	Operations Performance Model
personnel actual	Operations Performance Model

Object	Model
personnel actual property	Operations Performance Model
equipment actual	Operations Performance Model
equipment actual property	Operations Performance Model
physical asset actual	Operations Performance Model
physical asset actual property	Operations Performance Model
material actual	Operations Performance Model
material actual property	Operations Performance Model
material actual assembly	Operations Performance Model
operations capability	Operations Capability Model
personnel capability	Operations Capability Model
personnel capability property	Operations Capability Model
equipment capability	Operations Capability Model
equipment capability property	Operations Capability Model
physical asset capability	Operations Capability Model
physical asset capability property	Operations Capability Model
material capability	Operations Capability Model
material capability property	Operations Capability Model
material capability assembly	Operations Capability Model
process segment capability	Process Segment Capability Model
product definition	Product Definition Model
product segment	Product Definition Model
manufacturing bill	Product Definition Model
manufacturing bill assembly	Product Definition Model
production schedule	Production Schedule Model
production request	Production Schedule Model
production parameter	Production Schedule Model
production performance	Production Performance Model
production response	Production Performance Model
production data	Production Performance Model
production capability	Production Capability Model

9 Compliance

Any assessment of compliance of a specification shall be qualified by the following:

- a) The use of the terminology defined in this part
- b) The object models supported (Personnel, Material, Equipment, Process Segment, Operations Capability, Operations Definition, Operations Schedule, Operations Performance, Production Capability, Process Segment Capability, Product Definition, Production Schedule, and Production Performance)
- c) The use of objects listed in Clause 8 that are supported
- d) The use of the attributes for each supported object
- e) The relationships between the supported objects
- f) A statement of the total compliance concerning definitions, objects, attributes, and relationships or, in case of partial compliance, a statement identifying explicitly the areas of noncompliance.

Annex A (Normative) Production specific information

A.1 Product definition information

A.1.1 Product definition model

The production specific model is a specialized subset of the operations model with alternative object names for purposes of backward compatibility. New implementations should use the operations models.

The product definition is shown in Figure 19. It defines the shared information between product production rule, bill of material, and bill of resources. These three external models are represented by packages in Figure 19; their definitions are outside the scope of this standard.

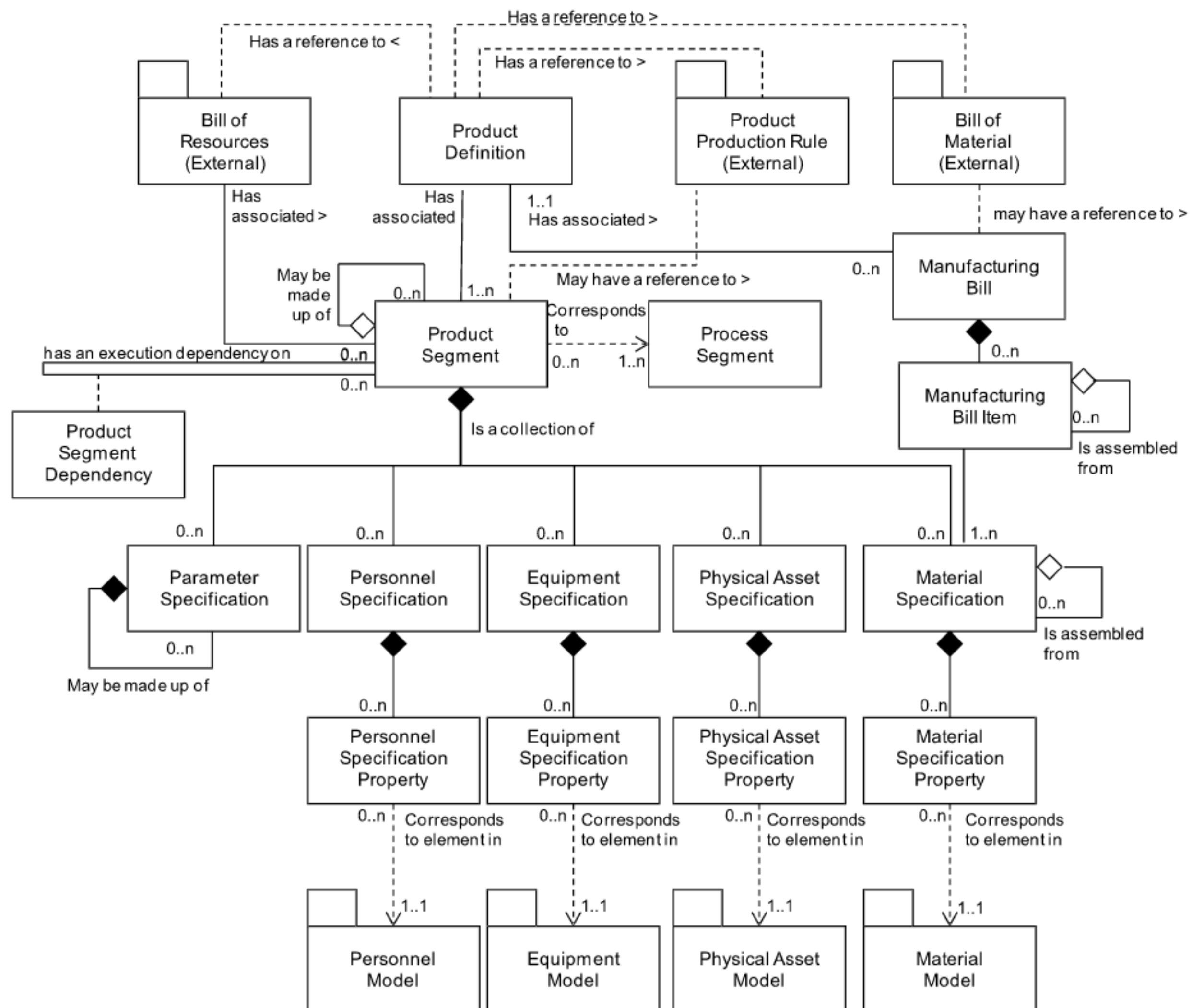


Figure 19 — Product definition model

Product production rules are defined as the information used to instruct a production operation how to perform the operation. Product production rules are production specific operations instructions. These may be called a general, site or master recipe (IEC 61512-1 and ANSI/ISA-88.01-1995 definition), standard operating procedure (SOP), standard operating conditions (SOC), routing, or assembly steps based on the production strategy used.

A.1.2 Product definition

A product definition contains a listing of the exchanged information about a product. The information is used in a set of product segments. A product definition has a reference to a bill of materials, a product production rule, and a bill of resources.

The attributes of a *product definition* are the same as an *operations definition*, as defined in Clause 6.1, except that *Operations type* is optional and if defined shall have the value "Production".

NOTE A product definition ID may be the same ID as a material definition.

A.1.3 Manufacturing bill

The identification of the material or material classes that are needed for production of the product shall be known as a manufacturing bill. Manufacturing bill objects contain an identification of materials that make up the items of a complete manufacturing bill.

The manufacturing bill includes all uses of the material in production of the product, while the product segment material specification gives just the amount used in a segment of production.

NOTE For example, a manufacturing bill may identify 55 Type C left-threaded screws, where 20 are used in one product segment, 20 in another product segment, and 15 in a third product segment.

The attributes of *manufacturing bill* are the same as the attributes for an operations material bill defined in Table 44.

A.1.4 Manufacturing bill item

Each material in a manufacturing bill is defined in a manufacturing bill item.

The attributes of a *manufacturing bill item* are the same as the attributes for an operations material bill item defined in Table 45.

A.1.5 Product segment

The values needed to quantify a segment for a specific product shall be a product segment. A product segment identifies, references, or corresponds to a process segment. A product segment is related to a specific product, while a process segment is product independent.

NOTE Examples include the requirement of a specific number of operators with specific qualifications.

The collection of product segments for a product gives the sequence and ordering of segments required to manufacture a product in sufficient detail for production planning and scheduling. The corresponding product production rule presents the additional detail required for actual production.

A product segment shall use zero or more resources, which correspond to an equipment specification, a personnel specification or a material specification. A product segment may have parameter values for parameters specified in the corresponding process segment.

A product segment may have a reference to a product production rule that corresponds to the rules required to implement the specific product segment when more granularity is needed than one product production rule for the product definition.

EXAMPLE There may be a Master Recipe (IEC 61512) for each product segment.

The attributes of a product segment are the same as an operations segment, as defined in Clause 6.1, except that operations type is optional and if defined shall have the value "Production".

A.1.6 Product parameter

The attributes for a product parameter are the same as the attributes for a parameter, as defined in Clause 6.1.6

A.1.7 Product segment dependency

The attributes for a *product segment dependency* are the same as the attributes for a *process segment task dependency*, as defined in Clause 6.1.15.

A.2 Production schedule

A.2.1 Production schedule model

A production schedule is a request for production. A production schedule is made up of one or more production requests. A production request is a request for production for a single product identified by a product production rule. A production request contains the information required by manufacturing to fulfill scheduled production. A production request contains at least one segment requirement, even if it spans all production of the product.

Figure 20 is the production schedule object model.

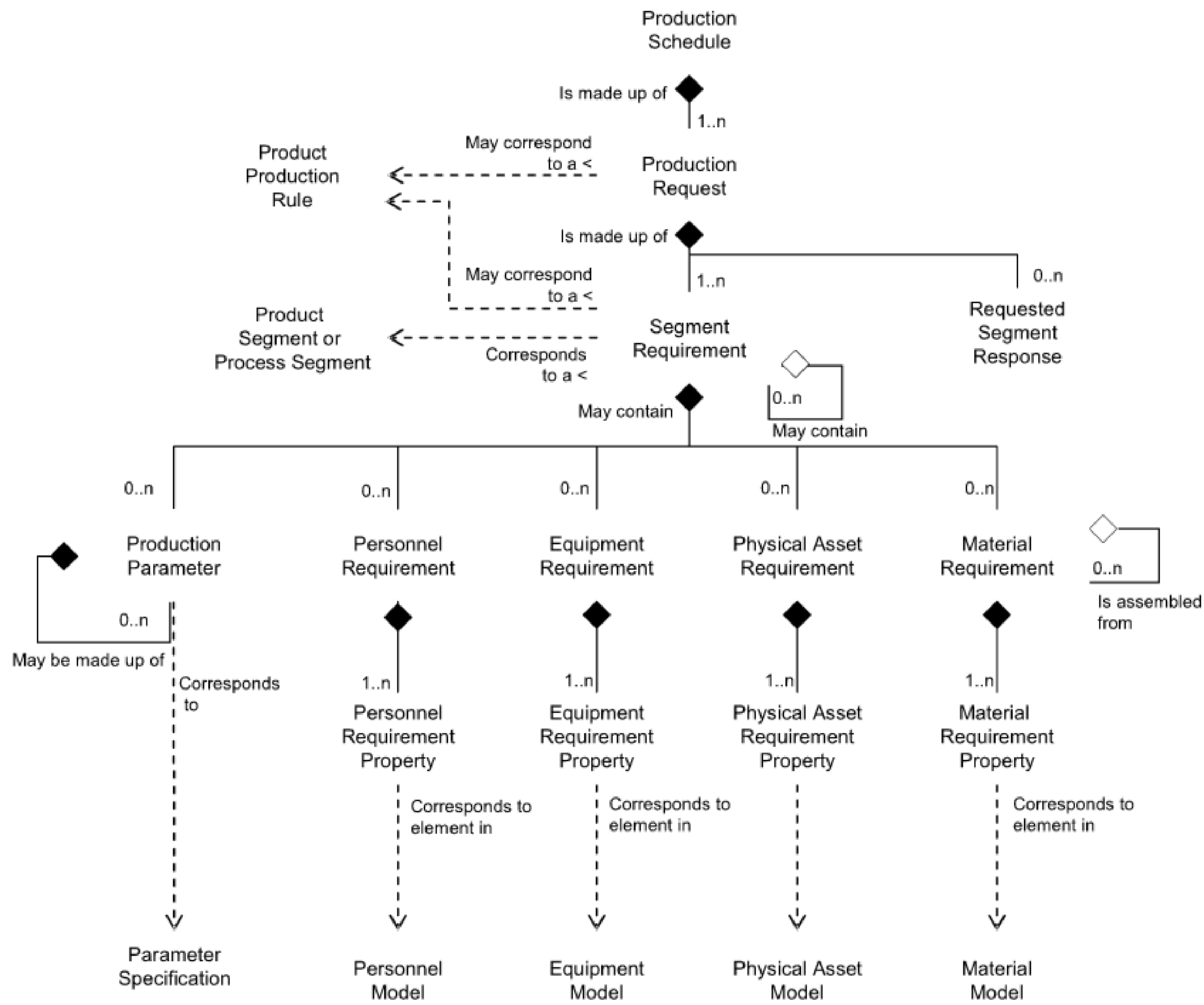


Figure 20 — Production schedule model

NOTE The previous version of this standard contained specific objects for each use type of materials. These objects were removed from this version. The removed objects are: Material Produced Requirement, Material Consumed Requirement, and Consumable Expected. An attribute of the Material Requirement Property is to be used to determine the use of the material.

A.2.2 Production schedule

A request for production shall be listed as a production schedule. A production schedule shall be made up of one or more production requests.

The attributes for *production schedule* are the same as *operations schedule* defined in Table 57, except that the *operations type* attribute is optional, and if specified shall be "Production".

A.2.3 Production request

A request for production for a single product identified by a product production rule shall be shown as a production request. A production request contains the information required by manufacturing to fulfill scheduled production. This may be a subset of the business production order information, or it may contain additional information not normally used by the business system.

A production request may identify or reference the associated product production rule. A production request shall contain at least one segment requirement, even if it spans all production of the product. If not uniquely given by the product production rule, then a segment requirement shall contain at least one material produced requirement with the identification, quantity, and units of measure of the material to be produced.

A production request may be reported on by one or more production responses. In some situations, the material identification, product production rule identification, and material quantity may be all that is needed for manufacturing. Other situations may require additional information. The additional information may be described in the production parameters, personnel requirements, equipment requirements, and material requirements.

The attributes of a production request are the same as an operations request and are defined in Table 58.

A.2.4 Production parameter

Information contained in the enterprise system that is required by the operation system for correct production shall be known as production parameters.

Production parameters may be either product parameters that show some characteristics of the product (such as paint color), or process parameters that present some characteristics of the production process (such as bake time).

NOTE Examples of production parameters are

- quality limits;
- set points;
- targets;
- specific customer requirements (such as purity = 99,95%);
- final disposition of the produced product;
- transportation information;
- other information not directly related to control (such as a customer order number required for labeling or language for labels).

The attributes for a production parameter are the same as for a segment parameter and are listed in Table 60.

A.3 Production performance

A.3.1 Production performance model

Production performance is a report on requested manufacturing and is a collection of production responses. Production responses are responses from manufacturing that are associated with a production request. There may be one or more production responses for a single production request if the production facility needs to split the production request into smaller elements of production.

Figure 21 is the production performance object model.

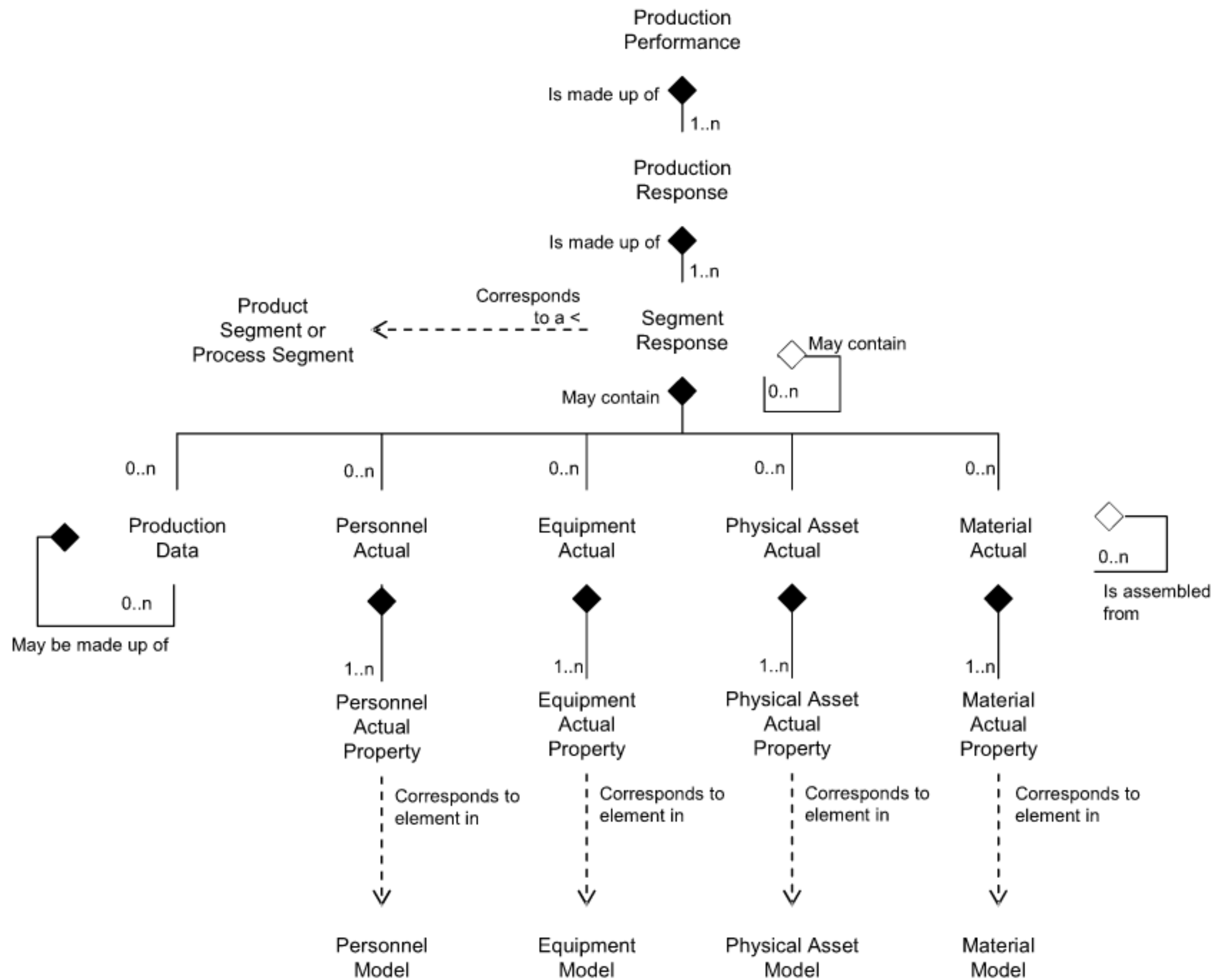


Figure 21 — Production performance model

NOTE The previous version of this standard contained specific objects for each use type of materials. These objects were removed from this version. The removed objects are: Material Produced Actual, Material Consumed Actual, and Consumable Actual. An attribute of the Material Requirement Property is to be used to determine the use of the material.

A.3.2 Production performance

The performance of the requested production requests shall be listed as production performance. Production performance shall be a collection of production responses.

The attributes for *production performance* shall be the same as the attributes for *operations performance* as defined in Table 69, except that the *operations type* attribute is optional and if specified shall be "Production".

A.3.3 Production response

The responses from manufacturing that are associated with a production request shall be used as production responses. There may be one or more production responses for a single production request if the production facility needs to split the production request into smaller elements of reported production.

NOTE For example, a single production request for the production of 200 gears may be reported on by 10 production response objects of 20 gears each because of manufacturing restrictions.

Production responses contain the items reported back to the business system, at the end of production or during production. The business system may need to know intermediate production response statuses, rather than waiting for the final production response status, because of cost accounting of material produced or intermediate materials.

The attributes for *production response* shall be the same as the attributes for *operations response* as defined in Table 70, except that the *operations type* attribute is optional and if specified shall be "Production".

A.3.4 Production data

Other information related to the actual products made shall be presented as production data.

NOTE Examples of production data are

- a customer order number associated with the production request;
- specific commercial notes from operations related to the customer order, such as order complete, order incomplete, or an anticipated completion date and time;
- quality information;
- certification of analysis;
- procedural deviations, such as an identification of an event used in another system and alarm information;
- process behaviour, such as temperature profiles;
- operator behaviour, such as interventions, actions, and comments.

The attributes for *production data* shall be the same as the attributes of *segment data*, as defined in Table 72.

A.4 Production capability

A.4.1 Production capability model

The production capability model is shown in Figure 22. Production capability information is the collection of information about all resources for production for selected times. This is made up of information about equipment, material, personnel, and process segments. Production capability describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

Production capability is defined as a collection of personnel capabilities, equipment capabilities, material capabilities, and process segment capabilities, for a given segment of time (current or future), and defined as committed, available, and unattainable.

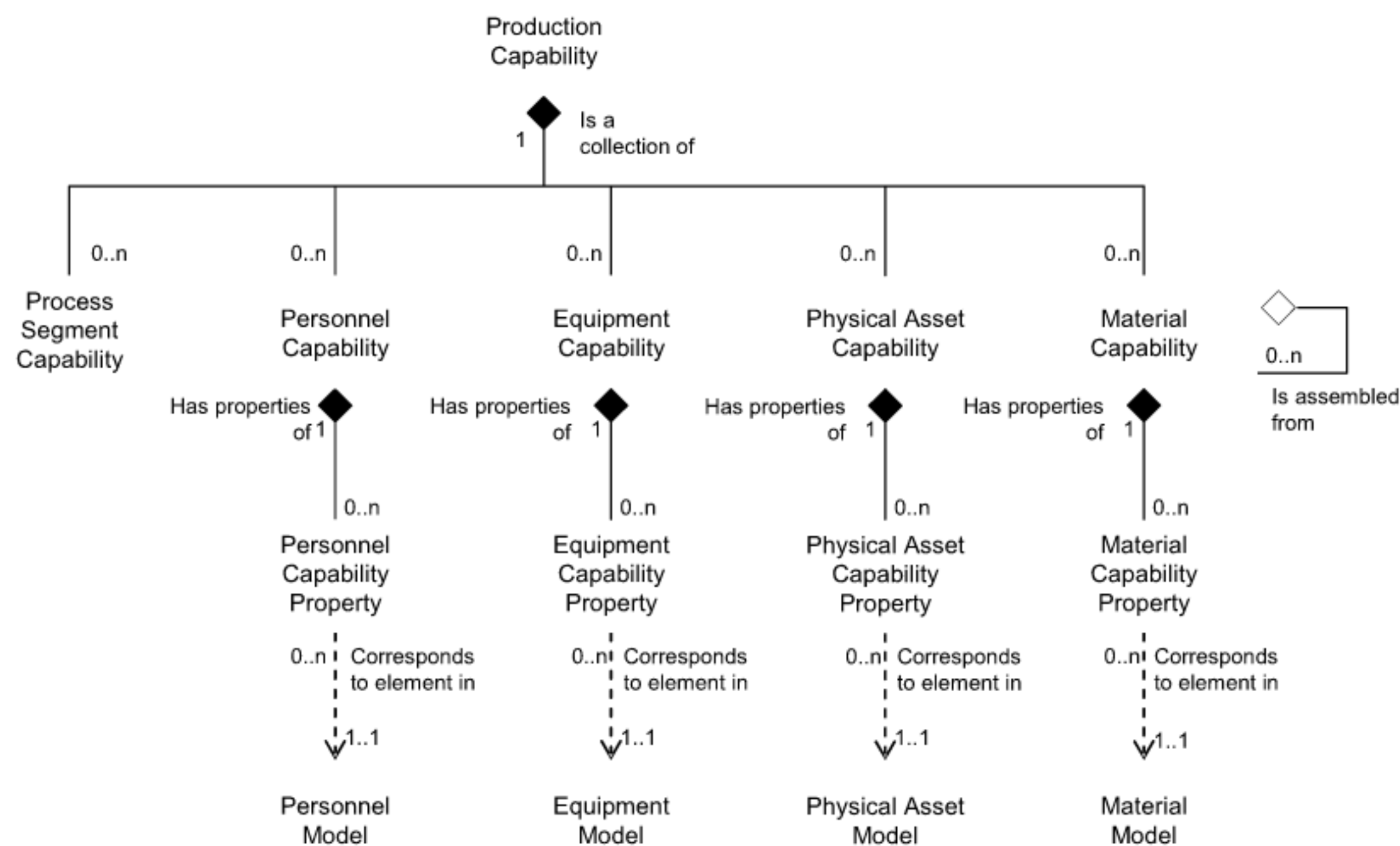


Figure 22 — Production capability model

A.4.2 Production capability

The attributes of *production capability* are the same as *operations capability* as defined in Table 81.

Annex B (Informative) Use and examples

B.1 Use and examples

This standard is expected to be used in the specification of interfaces (at Level 3 and Level 4) between new applications, between legacy applications, or between new applications and legacy applications. That may facilitate the usage of packaged software in a legacy application context, which may be the most powerful initial use of the standard.

Through the use of this standard the definition of the interface content may be provided faster and more accurately. In addition the specification of interface content may be easily reused. This will be facilitated by the correct use of compliance assessments that identify which object models are supported by the interface content specification.

Part 1 defines the categories of information that should be exchanged between Business Systems and Manufacturing Operations and Control Systems. Four (4) categories are defined;

- Product Definition
 - Production Capability
 - Production Schedule
 - Production Performance
- } Production Information

Each of these four (4) categories relies on the four (4) resources also defined in Part 1.

- Personnel
- Equipment
- Material
- Process Segment

Part 2 presents the corresponding UML models and attributes for the objects contained in the UML models. The UML models are software independent descriptions of the data exchange between Business Systems and the Manufacturing Operations and Control Systems.

UML relies on object-oriented methodology. Very briefly, this means that there are classes, subclasses and instances (objects). A class can for example be Car, and the instances can be “Mrs. Mine’s car” or “My car”. A class has attributes, and the instances have values on the attributes, e.g., the class Car has an attribute “License plate” whereas the Instance “Mrs. Mine’s car” has the attribute “license plate= ABC 123”.

Example - The following figure shows the UML model for Personnel.

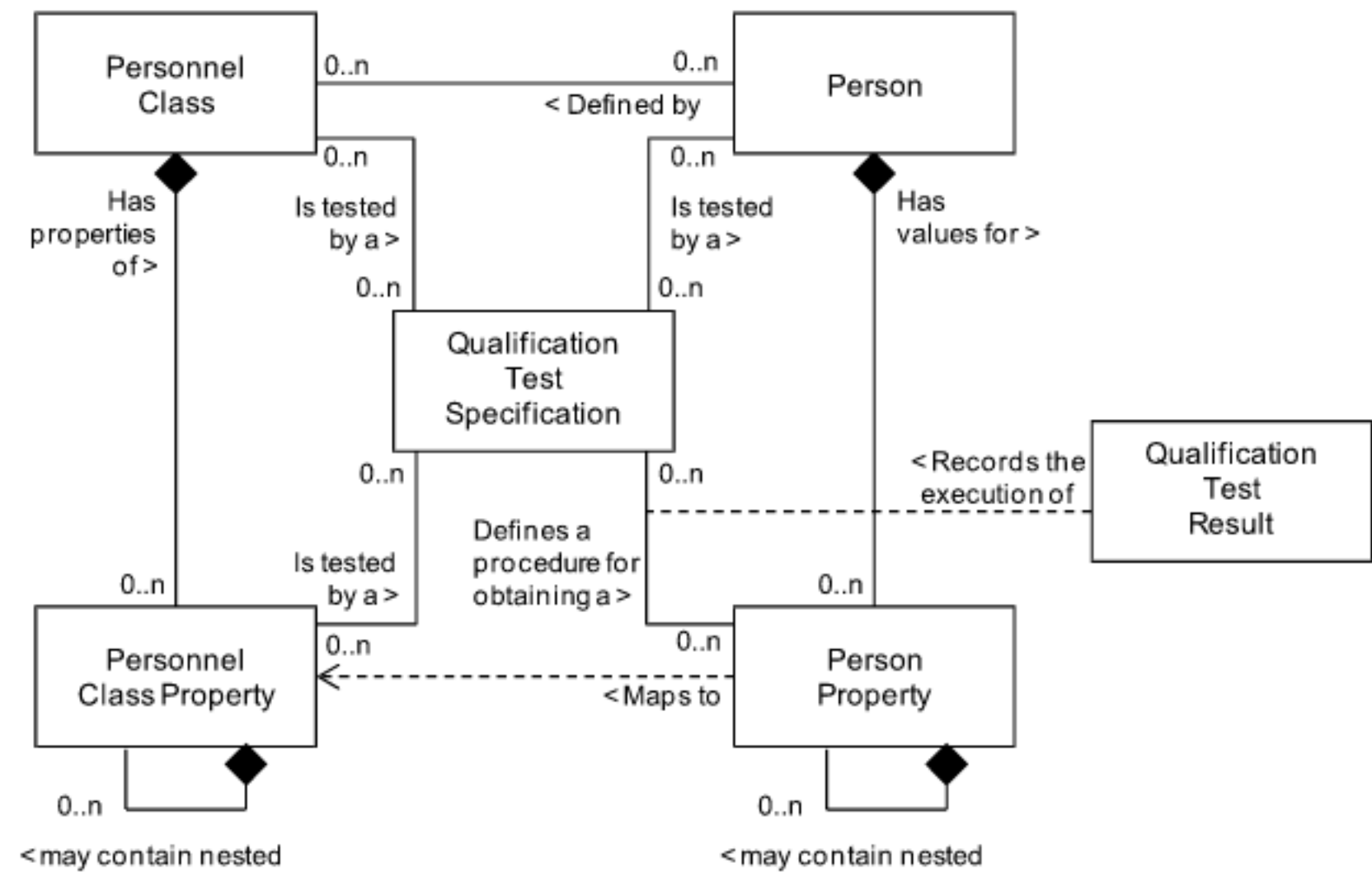


Figure B-1 — Personnel model

The model shown in Figure B-1, a copy of Figure 5, defines six (6) classes; person, personnel class, Person Property, Personnel class property, Qualification test Specification and Qualification Test Results.

Table B-1 shows the attributes for Person (a copy of Table 5).

Table B-1 — Attributes of person

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a specific person, within the scope of the information exchanged (<i>production capability, production schedule, production performance, ...</i>) The ID shall be used in other parts of the model when the <i>person</i> needs to be identified, such as the <i>production capability</i> for this person, or a <i>production response</i> identifying the person.	Employee 23	22828	999-123-4567	007
Description	Additional information about the resource.	Person Information	Maintenance Tech	Lab Tech	Driver
Name	The name of the individual. This is meant as an additional identification of the resource, but only as information and not as a unique value.	Jane	Jim	John	James

This means that the class Person should have ID, Description and Name as attributes.

Figure B-2 shows the class Person with the attributes, and two instances e.g. John Smith and Lou Brown.

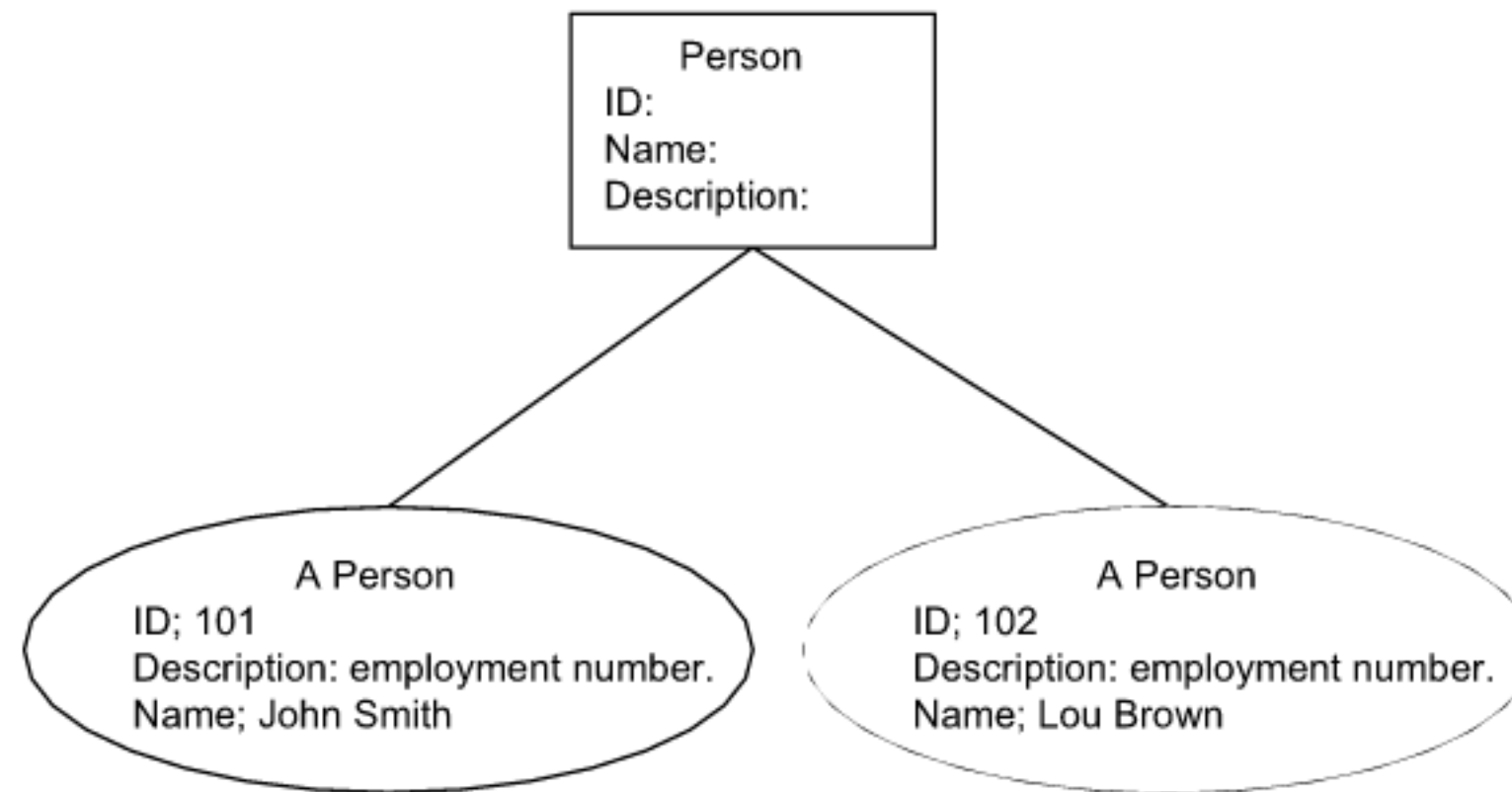


Figure B-2 — Instances of a person class

In the same manner there is a class for “Personnel Class” (Personnel Class should be thought of as Personnel Group/Category), the instances used depends on the application but could be e.g., engineers, night-shift workers, drilling-machine-operators etc.

Of course certain attributes for Classes will depend on the application. To support application specific attributes the “Property” should be used. The instances of the Properties will define the attributes for the corresponding Class. The UML model says that there can be none, one or many properties linked to the corresponding class as shown in Figure B-3.

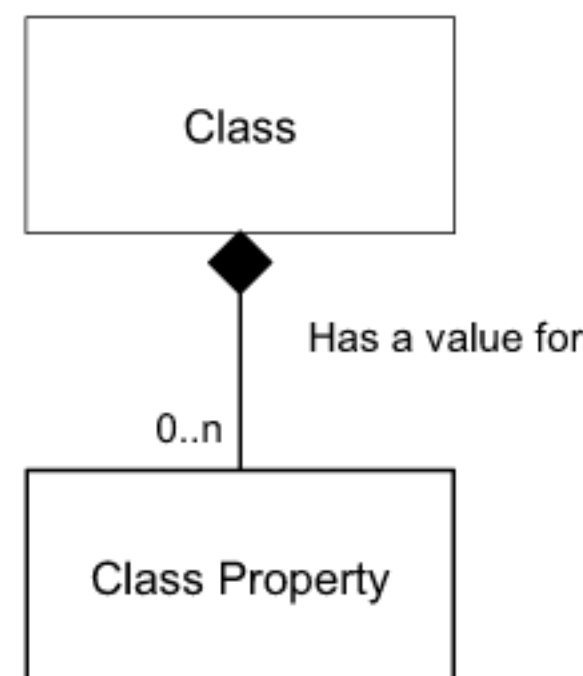
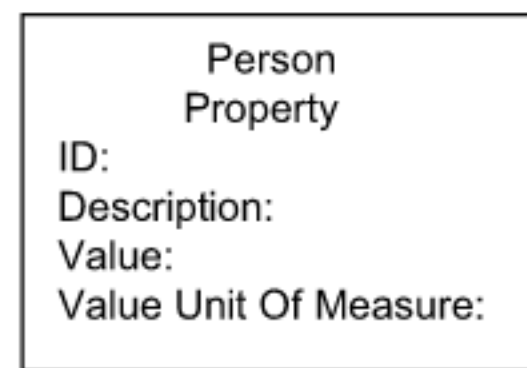


Figure B-3 — UML model for class and class properties

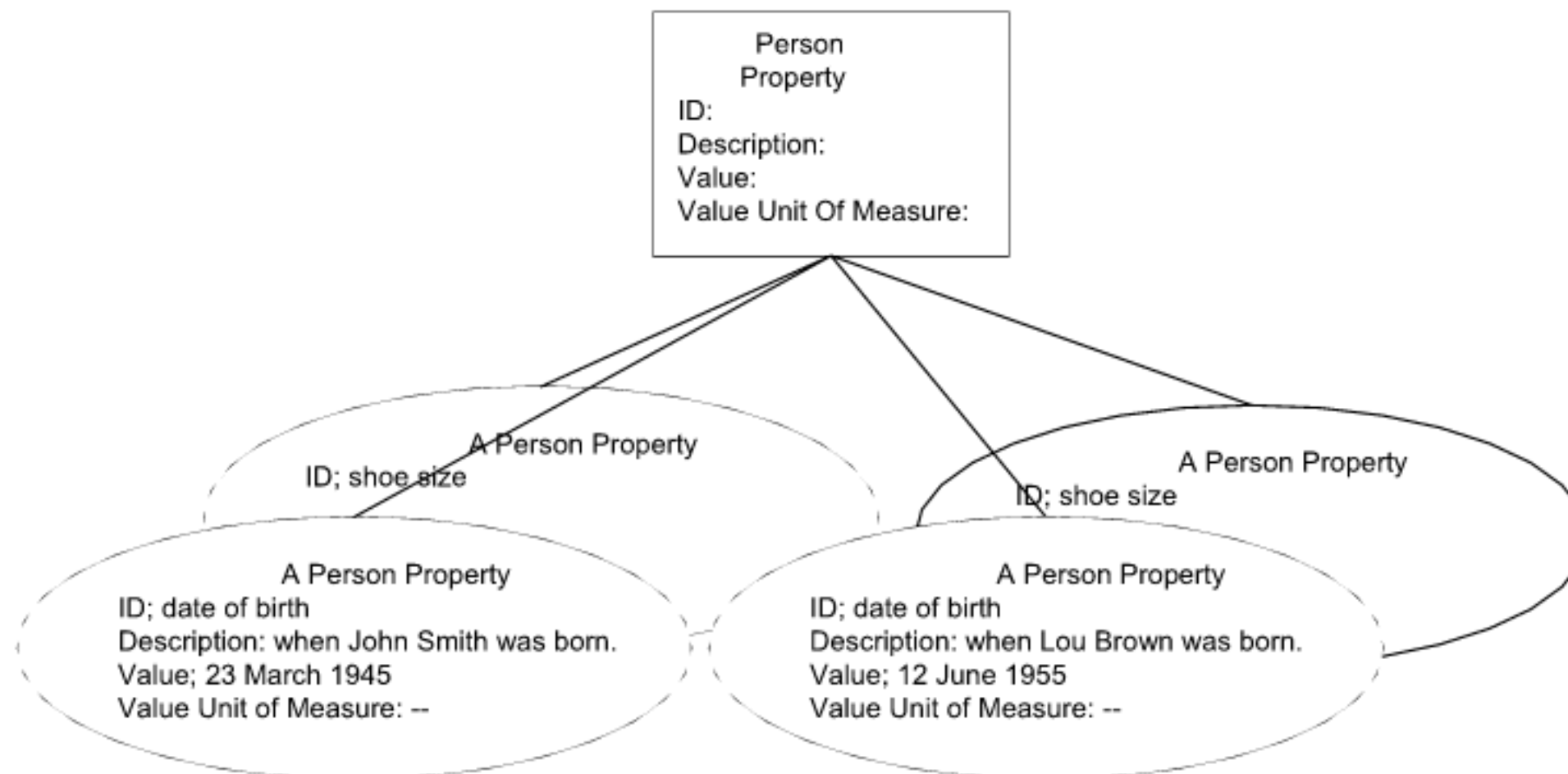
This means that all the instances of “Property” will effectively describe attributes to the class. Each instance of the class will contain values for the attributes.

EXAMPLE Certain attributes for Person as well as for Personnel Class depend on the application, e.g., it might be useful to exchange info about a person’s date-of-birth in one application but not in another. To support application specific attributes the “Person Property” or “Personnel Class Property” should be used. The instances of the Properties will define the attributes for the Person/Personnel Class. The UML model says that there can be none, one or many properties linked to Person/Personnel Class.

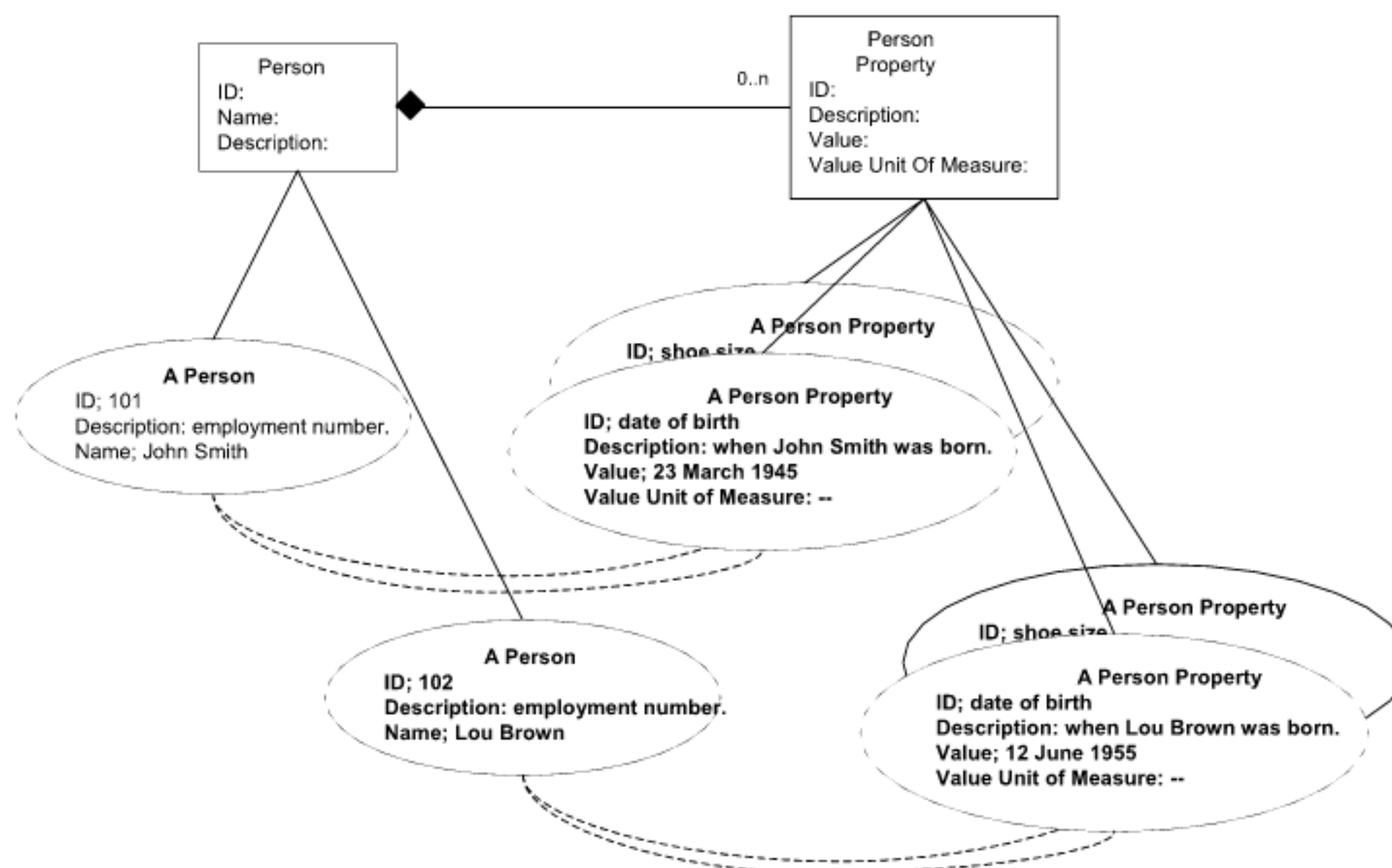
There is a class called Person Property. Each property is uniquely defined by its ID, Description, Value and Value Unit of Measure, as shown in Figure B-4.

**Figure B-4 — Class property**

The class can have for instances, two for the date of birth, one for John and one for Lou, and two for shoe sizes, one for John and one for Lou, as shown in Figure B-5.

**Figure B-5 — Instances of a person properties**

This means that each Person (instance) will have info about its properties, as shown in Figure B-6.

**Figure B-6 — Instances of person and person properties**

It is important to note that the classes must be defined within a product as well as support within a product to create and manipulate instances. However, the specific instances created will depend on the application.

B.2 Application of the standard

When designing or creating a system that implements the standard, one must make sure that the system supports the Classes needed (e.g. Person, Personnel Class, Person Property, Personnel Class Property etc). To completely comply with the standard all classes defined in the standard should be supported in the system.

Before the systems are put in execution mode it has to be decided what properties the classes should have (i.e., what instances the Property Class should have). Of course, only the properties that need to be exchanged between the systems have to be decided. The reasons this has to be decided include:

- Due to the internal structure of databases, some databases cannot be enlarged during execution mode, and therefore it needs to know in advance what properties should be supported
- Different systems might have different constraints on the naming of the properties e.g., a maximum length of property-name, the usage of upper and lower case letters.
- Different systems might be developed in different languages, e.g., in one system all properties are presented in French, whereas in another one, the properties are presented in English.

During execution, data regarding the instances can be exchanged. The data exchanged can be implemented in many different forms. One possibility is through databases, another possibility is through XML and XML schemas that have been developed in accordance with the models of this standard.

B.3 Database mapping of the models

If a database is used for data exchange, then there are many different ways of structuring the database. Tables B-2 and B-3 are included as examples of a data base structure that can be used to contain the data. The attribute “Key” indicates a unique value that may be required for relational integrity.

Table B-2 — Database structure for person

TABLE: Person		
ID	Description	Name

Table B-3 — Database structure for person property

TABLE: Person Property				
ID	Description	Value	Value Unit Of Measure	Key

When the system is in execution the database could contain the information shown in Table B-4 and Table B-5.

Table B-4 — Database for person with data

TABLE: Person		
ID	Description	Name
101	The employment number	John Smith
102	The employment number	Lou Brown
103	The employment number	Jane Mine

Table B-5 — Database for person property with data

TABLE: Person Property				
ID	Description	Value	Value Unit Of Measure	Key
Date of Birth	Indicates when a person is born	1945-03-23	YYYY-MM-DD	101
Shoe size	Indicates the shoe size of a person	43		101
Date of Birth	Indicates when a person was born	1955-06-12	YYYY-MM-DD	102
Shoe size	Indicates the shoe size of a person	45		102
Date of Birth	Indicates when a person is born	1969-12-24	YYYY-MM-DD	103
Shoe size	Indicates the shoe size of a person	38		103

B.4 XML usage

If a XML documents are used for data exchange, then there are many different ways of structuring the documents. The structure for an XML document is defined in a “schema”. A schema is the equivalent of a data base table definition.

Figure B-7 illustrates a possible XML schema for “Person”. The schema defines a place for ID, Description, Name, the person properties, and a place to contain the list of Personnel Classes the person belongs to. A Person (instance) is defined by its ID, Description, Name, PersonProperty, and PersonnelClassID. The ID, Description and Name, correspond to the attributes ID, Description and Name defined in this party.

PersonnelClassID is defined as the ID of a personnel class. PersonnelClassID (there may be many) contains a link to instances of PersonnelClass.

PersonProperty is defined as a complex type that contains the property ID, description, and value.

```
<xsd:complexType name = "PersonType">
  <xsd:sequence>
    <xsd:element name = "ID" type = "xsd:string"/>
    <xsd:element name = "Description" type = "xsd:string"
      minOccurs = "0"
      maxOccurs = "unbounded"/>
    <xsd:element name = "Name" type = "xsd:string"/>
    <xsd:element name = "PersonProperty" type = "PersonPropertyType"
      minOccurs = "0"
      maxOccurs = "unbounded"/>
    <xsd:element name = "PersonnelClassID" type = "PersonnelClassIDType"
      minOccurs = "0"
      maxOccurs = "unbounded"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:simpleType name="PersonnelClassIDType">
  <xsd:restriction base="xsd:string">
  </xsd:restriction>
</xsd:simpleType>
```

Figure B-7— XML schema for a person object

PersonProperty contains the instances of PersonProperty (there can be many). A PersonProperty (instance) is defined by its ID, Description, Value, and Value Unit of Measure. The ID, Description and Value and Value Unit of Measure, correspond to the attributes ID, Description and Name defined in this part.

A **PersonProperty** (instance) could be defined in the schema shown in Figure B-8

```
<xsd:complexType name = "PersonPropertyType">
  <xsd:sequence>
    <xsd:element name = "ID" type = "IDType"/>
    <xsd:element name = "Description" type = "DescriptionType"
      minOccurs = "0" maxOccurs = "unbounded"/>
    <xsd:element name = "Value" type = "ValueType"
      minOccurs = "0" maxOccurs = "unbounded"/>
    <xsd:element name = "ValueUnitOfMeasure" type = "ValueUOMType"
      minOccurs = "0" maxOccurs = "unbounded"/>
    <xsd:element name = "QualificationTestSpecificationID"
      type = "QualificationTestSpecificationIDType"
      minOccurs = "0" maxOccurs = "unbounded"/>
    <xsd:element name = "TestResult" type = "TestResultType"
      minOccurs = "0" maxOccurs = "unbounded"/>
  </xsd:sequence>
</xsd:complexType>
```

Figure B-8 — XML schema for person properties

During execution an XML document is created and the values of the attributes are filled in and exchanged between the systems. Figure B-9 illustrates a sample XML document, matching the schema above that contains person and person property information.

```
<PersonType>
  <ID> 101</ID>
  <Description>Employment Number</Description>
  <Name>John Smith</Name>
  <PersonProperty>
    <ID>date-of-birth</ID>
    <Description>indicates when a person is born</Description>
    <Value>1945-03-23</Value>
    <Value Unit of Measure> YYYY-MM-DD
  </Value Unit of Measure>
    <ID>Shoe size</ID>
    <Description>indicates the shoe size</Description>
    <Value>43</Value>
  </ PersonProperty >
  <PersonnelClassID>{night-shift-operator, engineer}
</PersonnelClassID>
</PersonType>
```

Figure B-9 — Example of person and person property

The information about an instance (e.g., Product manager or Engineer) of **PersonnelClass** could be exchanged in a separate XML schema, as shown in Figure B-10.

```
<PersonClassType>
<ID>Engineer</ID>
<Description> a registered professional engineer</Description>
  <PersonnelClassPropertyType>
    <ID>Engineer's License Number</ID>
    <Description>"The official engineer's license number"
    </Description>
  </PersonnelClassPropertyType>
</PersonClassType>
```

Figure B-10 — Example of person class information

Since the XML schemas or the objects and their attributes might not be implemented or called the same thing inside different systems, it might be required to have an “adapter/translator” inside the systems. This “adapter/translator” translates from the Part 1 terminology to the terminology used within the different systems. Figure B-11 illustrates an adaptor that maps property IDs and property types (date formats).

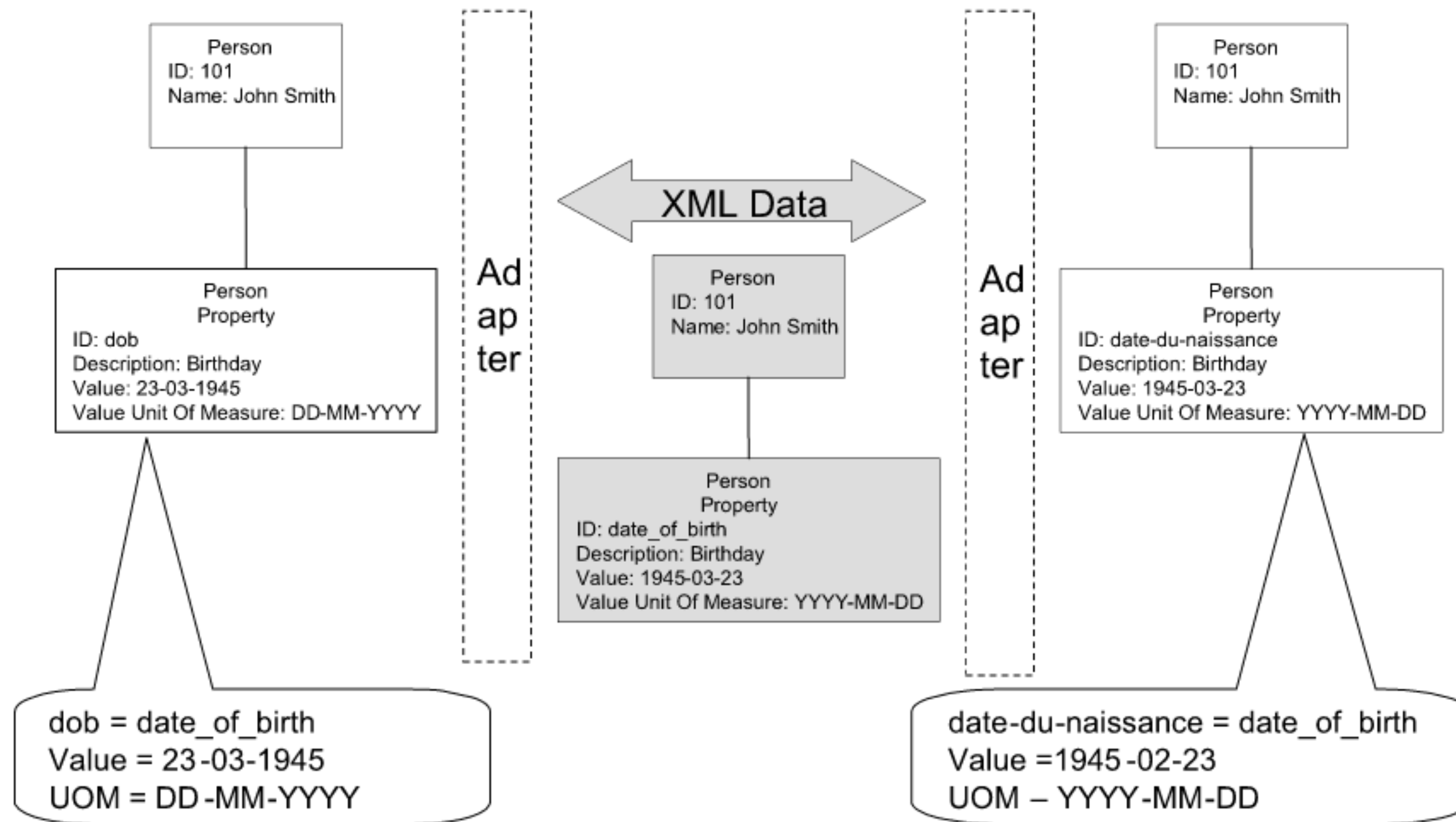


Figure B-11 — Adaptor to map different property IDs and values

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Annex C

(Informative)

Example data sets

C.1 Introduction

The following sections contain example data sets, based on the Part 2 models and attributes.

C.2 Material model example

This is a simplified example of material information that may be used in the food processing industry. The example presents shared information about a material class (Pork), a material definition (Pork 80% Lean), a material lot, and a material subplot. In a full example there may be multiple material classes and material description information sets that are shared, with lot and subplot dynamically shared. Indentation of objects is used to illustrate the relationship between the objects.

Material Class

ID - Pork
Description -
Properties

ID - Lethal Heat
Description - Temperature to kill bacteria
Value - 160
Units of Measure - Degrees F

ID - Receiving Temperature Target
Description -
Value - 32
Units of Measure - Degrees F

ID - Receiving Temperature Max
Description -
Value - 36
Units of Measure - Degrees F

ID - Receiving Temperature Min
Description -
Value - 28
Units of Measure - Degrees F

ID - Maximum Allowable Cut Time
Description - Time since cut
Value - 3
Units of Measure - Days

Material Definition

ID - Pork 80
Description - Boneless pork cut up with a target lean percentage of 80
Value -
Unit of Measure -
Properties

ID - Percentage Lean
Description -
Value - 80
Units of Measure - Percentage

QA Test Specification

ID - JackSpratTest1
Description - Test to determine percent of fat.

Version - 1997-04-02

ID - Percentage Fat
Description -
Value - 20
Units of Measure - Percentage

Material Lot

ID - 20000115091345
Description -
Status approved
Properties

ID - Delivery Temperature
Description - Temperature at delivery
Value - 37.5
Units of Measure - Degrees F

QA Test Result

ID - 2000-01-16-4930-TEMP
Description - Internal temperature of pork
Date - 2000-01-16
Result - Failed
Expiration - None

ID - Cut
Description - Cut Date
Value - 2000-01-14
Units of Measure -

ID - Expiration
Description - Expiration Date
Value - 2000-01-17
Units of Measure -

ID - Fat
Description - Actual Percent Fat
Value - 20
Units of Measure - Percent

QA Test Result

ID - 2000-01-16-4930-SPRAT
Description -
Date - 2000-01-16
Result - Pass
Expiration - None

ID - Lean
Description - Actual Percent Lean
Value - 80
Units of Measure - Percent

QA Test Result

ID - 2000-01-16-4930-SPRAT
Description -
Date - 2000-01-16
Result - Pass
Expiration - None

Material SubLot

ID - 20000115091345-1
Description -
Storage Location - Tote 392, Level 3, Rack 49
Value - 200
Unit of Measure - Pounds

ID - 20000115091345-2
 Description -
 Storage Location - Tote 852, Level 3, Rack 50
 Value - 300
 Unit of Measure – Pounds

C.3 Equipment Model Examples

Pulp and Paper Example

Enterprise	Site	Area	Work Center	Work Unit	Equipment	Notes
Paper Producer						
	Deep Woods River Site					Integrated Paper Mill Complex
		Wood Preparation Plant				
			Rail Yard			Storage
			Saw Mill			Continuous
				Slasher Deck		
				Splitting		
				Conveyor		
			Wood Room			
				Debarking		
				Chippers		
				Screend		
				Chip Conveyors		
				Chip Bins/Silos		Storage
				Grinders		
			Wood Yard			Storage
				Pile A		
				Pile B		
				Pile C		
		Steam Plant				
			Boiler Room			
				Furnace #1		
					Stack	
					ESP	Environmental Controls - Electrostatic Precipitator
				Boiler #1		
					Gauges & Instruments	
		Pulp Mill -- Chemical pulp -- Kraft process				Batch (product) / Continuous (machine operation)
			Cooking & Washing -- wood chips			
				Chip Storage		Storage
				White Liquor Storage		Storage

				Digester		
				Blow Tank		
				Washers		
			Acid Plant			Chemical Recovery System
				Black Liquor Storage		Storage
				Evaporators		
				Recovery Furnace		
				Dissolving Tank		
				Green Liquor Storage		Storage
				Slaker		
				Clarifier		
				Lime Mud Washer		
				White Liquor Storage		Storage
				Lime Kiln		
			Steam Plant			
				Refuse Boilers		
			ByProducts			Storage
			Pulp Processing			
				Bleaching		
				Washer Vacuum		
				Centrifugal Screening		
				Pressure Screening		
				Pulp Press		
		Paper Mill				Batch (product) / Continuous (machine operation)
			Beater Room			
				Beating Engine #1		
			Machine Room			
				Paper Machine #2		West End
					Screens	
					Head Box	
					Wire Pit	
					Press	
			Wet End			
				Paper machine #2		Dry End
					Drying Section	
					Calendar Stack #1	
					Calendar Stack #2	
					Reeler	
					Winder	
				Machine Drive		
				Roll Handler/Conveyor		
				Roll Storage		Storage

		Finishing				Discrete
			Coating			
				Coater # 1		
					Coater Mix	
					Coater	
					Dryer	
				Supercalendar # 1		
				Coater # 2		
				Supercalendar # 2		
			Slitting -- Reels			
				Slitter # 1		
					Knife Set	
					Kickup	
				Conveyor		
			Sheeting			
				Sheeter		
				Stacker		
				Bundler		
		Shipping Warehouse				Storage
		Lumber Mill				Lumber / board

Semiconductor Manufacturing

Site	Area	Work Center/ Work Cell	Work Unit	Equipment	Notes
					Assumption process starts with SOI wafers (Silicone on Insulation) that were purchased
FAB 1					
	Front End				
		Deposition			
			CVD	Deposition Tools	CVD Chemical Vapor Deposition
				Thickness Tool	
			PVD		PVD (Physical Vapor Deposition
		Metrology		Thickness Tool	Thickness Defect
				Defect Tool	
				Characteristics	
		Polishing	CMP		CMP Chemical Mechanical Polishing (Wafer is ready for the next step)
		Lithography		Tools	Electrical Circuit Mask
		Etch		Tools	
		Furnace		Tools	
					Repeat the above steps over and over until the wafer of devices is built
	Back End				
		Passivation			Preparation for pad bonding
		Bonding			
		Dicing			
		Packaging			
		Test			

C.4 Personnel model example

This is a simplified example of personnel information that might be used in the petrochemical processing industry. The example lists shared information about personnel classes and persons, including qualification test information.

Personnel Class

ID - Operator Level A

Description - Top level operator certification for petrochemical plant

ID - Operator Level B

Description - Basic level operator certification for petrochemical plant

ID - Operator

Description - Operators for petrochemical plant

Properties

ID - MTBE Process Certification

Description - Each completed level of certification test

Value - TRUE, FALSE

Units of Measure -

Qualification Test Specification

ID - PC-MTBE-992828

Description - Test to determine level of MTBE certification.

Version - 1997-04-02

ID - PO Refining Process Certification

Description - Each completed level of certification test

Value - TRUE, FALSE

Units of Measure -

Qualification Test Specification

ID - PC- PO-Refining -992828

Description - Test to determine level of PO Refining certification.

Version - 1997-04-02

ID - Push-Up Certification

Description - Operator is temporarily able to perform the higher up function

Value - TRUE, FALSE

Units of Measure -

Person

ID - 999-63-8161

Description -

Name - John Doe

Properties

ID - MTBE Process Certification

Description - Each completed level of certification test

Value - TRUE,

Units of Measure -

Qualification Test results

ID - PC-MTBE-992828-2000-10-12

Description - Test to determine level of MTBE certification.

Result - Passed

Expiration - 2000-12-15

ID - PO Refining Process Certification

Description - Each completed level of certification test

Value - FALSE

Units of Measure -

ID - Push-Up Certification

Description - Operator is temporarily able to perform the higher up function
Value - FALSE
Units of Measure -
ID - Fire Team Qualified
Description - Operator has been trained to aid in fire-fighting
Value - TRUE
Units of Measure -

Personnel Classes

ID - Operator
ID - Operator Level B
ID - Fire Team Qualified

C.5 Production capability example

This is a simplified example of production capability information for a crude oil pipeline shipment system. This example illustrates the future committed definition of the capability of a crude oil pipeline segment, using a specific segment of time.

Production Capability

ID - Caspian Crude Oil Pipeline
Location - Tengiz-Atyrau Pipeline Segment
Element Type - Area
Start Time - August 1, 2001
End Time - August 31, 2001

Material Capability

Description - Segment Throughput
Material Class - Crude Oil - Type A
Capability Type - Committed
Start Time - August 1, 2001 6:00
End Time - August 2, 2001 6:00

Material capability property

ID - Viscosity
Value - 104
Unit of Measure - cp (centipoise)

Material capability property

ID - Entry Temperature
Value - 30
Unit of Measure - Deg C

Material capability property

ID - Ground Temperature
Value - 18
Unit of Measure - Deg C

C.6 Production performance example

This is a simplified example of production performance information for a crude oil pipeline shipment system. This example illustrates an example of a day of production for crude oil pipeline segment.

Production Performance

ID - Caspian Crude Oil Pipeline
Start Time - August 1, 2001
End Time - August 2, 2001
Location - Tengiz-Atyrau Pipeline Segment
Type - Area

Production Response

ID - Daily Production
Start Time - August 1, 2001 - 6:00
End Time - August 2, 2001 - 6:00

Segment Response

ID - Daily Production

Production Data

Name - Total Pipeline Throughput
Value - 126,000
Unit of Measure - Metric Tons / Day

Material Produced Actual

Description- Crude Shipped, Shipper A
Material Lot - SampleNumber 28883992021
Quantity - 63,000
Unit of Measure - Metric Tons / Day

Material produced actual property

ID - Average Viscosity
Value - 103
Unit of Measure - cp (centipoise)

Material produced actual property

ID - Entry Temperature
Value - 32.3
Unit of Measure - Deg C

Annex D **(Informative)** **Questions and answers about object use**

D.1 Introduction

This section contains notes about the expected use of the object models, basically recorded as notes between committee members.

D.2 Inflow materials

QUESTION:

In many continuous production facilities the material inflow into the process is an important element of shared information. Does the *product segment* present the material inflow into production, or can it be presented in the *product production rule*?

ANSWER:

There are no attributes in the *product segment - material specification*, or the *process segment - material segment specification* that detail if the material is produced or consumed.

To be consistent with the rest of the models we should be able to specify the inflow (consumed) material in either the *process segment*

EXAMPLE Running a distillation segment consumes a material.

or in the *product segment* (producing a material also consumes a material). This information is needed for scheduling, so it should be included in the exchanged information. The information should probably be recorded as a property of either the *product segment - material specification* or of the *process segment - material segment specification*, depending on the industry needs.

D.3 Multiple products per process segment

QUESTION:

In many continuous and batch industries a single process segment may produce multiple products. What describes the whole picture that multiple product segments are associated with a certain process segment?

EXAMPLE In a system where materials A, B and C are used to produce products X and Y at a certain equipment in a single batch, where Y could be a by-product.

- There may be only one process segment.
- There may be two product segments, for X and Y.
- The product production rule describes that X is made from A, B and C, and Y is made from A, B and C.
- Then, what describes that the X and Y are “brother” products?
- Is it a parent product segment, which contains product segment X and Y?

ANSWER:

This part of 62264 does not model the object relationships in IEC 62264-1, so this is a matter of implementation. The most common approach to this problem seems to be to list a process segment for the process of consuming (A,B,C) and generating (X,Y).

The *process segment - material segment specifications* would contain the appropriate ratios (assuming they are constant), such as [50% A, 30% B, 20% C] to produce [75% X, 25% Y]. There would be *product segments* for X and Y, but they would not maintain the inflow (consumed) information in the *product segments*.

Since the exact relationship between the amounts of material may also be equipment specific, the most common approach would be to create multiple *process segments* that show the consumed and produced materials in the ratios appropriate for each set of unique *equipment*.

In petrochemical refining and chemical production it is even more complicated, since the ratio of produced material can vary based on production parameters (such as temperatures of trays in distillation columns) and on the specific properties of the consumed materials (such as the sulfur content of the oil). In those cases, if the information needed to be exchanged on a regular basis, the most common approach would be to extend the *process segment - material segment specifications* to include the mathematical relationships, such as an equation, tables, or LP, or a reference to an LP, equation, or table.

D.4 Process segments vs. product segments

QUESTION:

What is the difference between process segments and product segments?

ANSWER:

A *process segment* presents a production activity and what resources are needed to execute the activity, at the level of detail required for business processes, such as planning or costing. Business segment is a synonym for process segment.

EXAMPLE Making a bicycle frame requires an assembly jig, a bending machine, and an assembler for 30 minutes.

The same resources may be associated with more than one process segment.

A *product segment* lists what resources are needed to make a specific product, at the level of detail required for planning or costing.

EXAMPLE What is needed to make a 27-inch bicycle; 2 27-inch wheels, 1 27-inch frame, 1 seat, 15 screws, 1 hour of a tall test cyclist, etc.

A product is defined by one or more product segments.

Any specific implementation may require more than one *product segment*, more than one *process segment*, or a combination of both to fully describe a planning or costing view of production.

The concept of “*process segment*” is a planning view of production describing the resources needed for production. In the continuous industries, this usually corresponds to scheduled/planned operations within production units.

EXAMPLE A *process segment* in an oil refinery would be the material flowing through a catalytic cracker. The “segment” of production would be the use of the catalytic cracker. The scheduled element would be either the flow rate through the cracker, or the total amount of material through the cracker during a period of time.

In addition, when multiple products are produced from the same process, then *process segments* are generally considered a better description of production.

EXAMPLE A distillation *process segment* (associated with a distillation column) could process many product segments (one per outflow).

The “*product segment*” is a planning view of production where the product definition is more descriptive than the process definition.

EXAMPLE There may be many products made using a “semiconductor chip insertion process”, but the product definition is the key determination of the product produced, not the process itself.

Process segments are generally considered a sufficient description when the processes are relatively generic and do not themselves define products. *Product segments* are important in flexible-discrete and batch manufacturing, where the ability to include specific characteristics for each product is possible.

Table D-1 — Definition of segment types

Description	Process Segment	Product segment
Category of Information	Production Information	Product Definition/Description
Definition	Equipment planning view of production	Product planning view of production
Dependence	Usually independent of product	Usually dependent on product

D.5 Production parameter references

QUESTION:

Is a production request - segment request - production parameter a reference to a parameter of the associated product segment or the process segment?

ANSWER:

Either, and this ambiguity was used on purpose, because the specifying committee had examples for both cases.

EXAMPLE A *production parameter* may be a paint color to be used, this could be defined as being in either the *product segment* (if each product can be painted a different color in the same production step) or in the *process segment* (if all products going through the production step must be painted the same color).

D.6 How class name and property IDs are used to identify elements

QUESTION:

The object models all follow the same pattern of class name, with an optional property ID. How is that used to identify elements?

ANSWER:

While properties can be used to contain information about resources, they can also be used to identify subsets of resources.

Resources can sometimes be described using a class name, such as “Operators,” or as class names plus some differencing property, such as “Operators” with ranking of “Master,” “Standard” or “Junior.” In the models where a “quantity” is needed, the models all follow the same pattern. There is always a reference to a class (such as *Personnel Capability*) that may have an optional quantity.

EXAMPLE 1 It may require 10 man-hours of operator time available for a shift. If the element described is a subset of the class, such as only “Master” operators, then a property object is used to contain the discriminating information, and the quantity information.

EXAMPLE 2 *Personnel Property Capability* would define 4 man-hours of “Master” operator time available for a shift.

This model allows significant flexibility by allowing a single class definition (e.g., Operators), without a quantity listing, and multiple property descriptions (e.g., Master, Standard, and Junior operators) each with their own property definition. The left part of Figure D-1 illustrates how a *Personnel Capability* would describe a capability of 8 operators. The right part illustrates how the capability of different ranking of operators would be defined. The *Personnel Capability Property, Ranking*, is used to differentiate the capability of different types of operators.

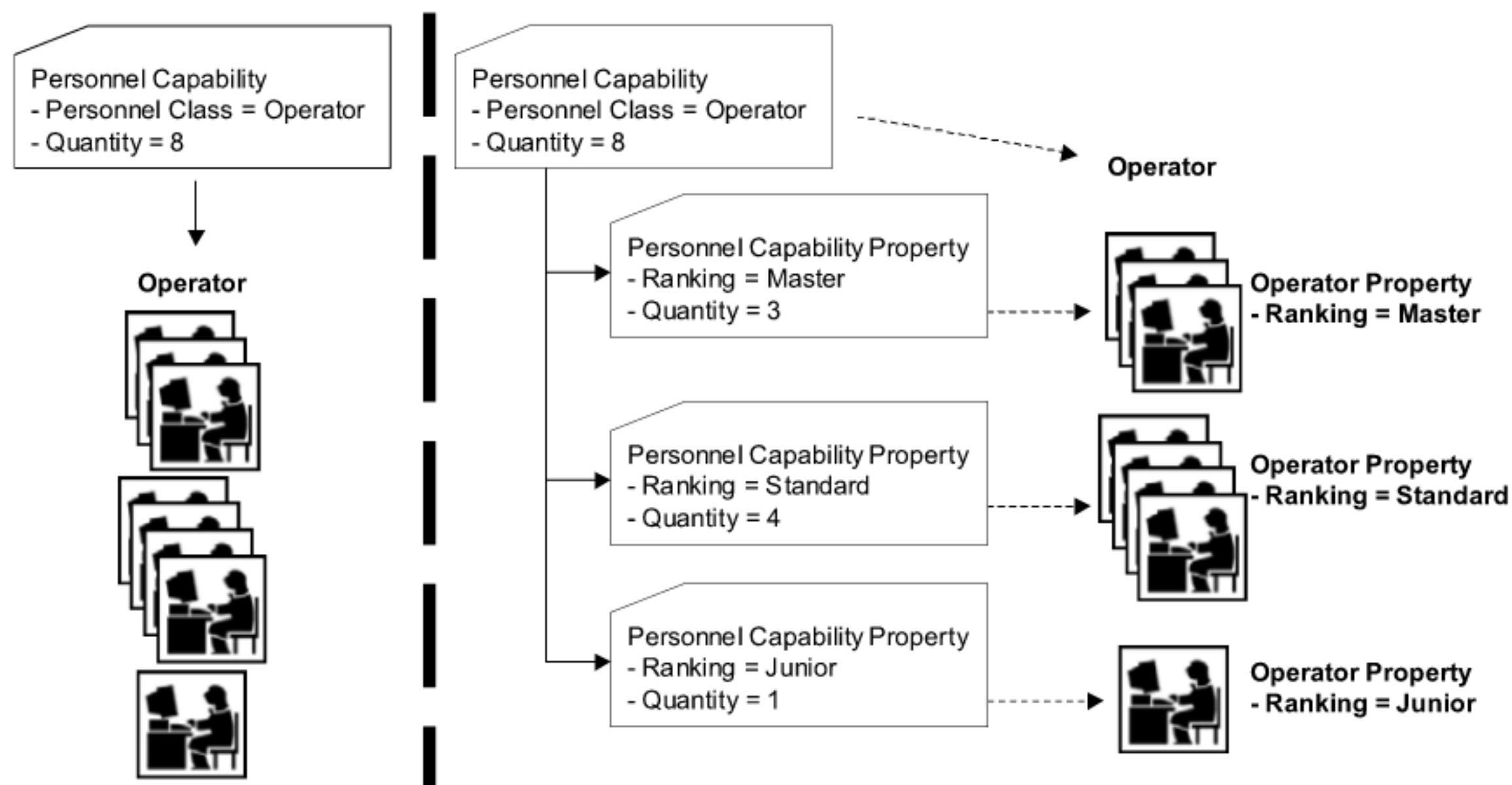


Figure D-1 — Class and property IDs used to identify elements

This concept applies to the following objects:

- Personnel Capability
- Material Capability
- Equipment Segment Capability
- Equipment Capability
- Personnel Segment Capability
- Material Segment Capability

- | | |
|-----------------------------------|-----------------------------------|
| — Personnel Segment Specification | — Equipment Segment Specification |
| — Material Segment Specification | — Personnel Specification |
| — Equipment Specification | — Material Specification |
| — Personnel Requirement | — Equipment Requirement |
| — Material Produced Requirement | — Material Consumed Requirement |
| — Consumable Expected | — Personnel Actual |
| — Equipment Actual | — Material Produced Actual |
| — Material Consumed Actual | — Consumable Actual |

D.7 Possible capability over-counts

QUESTION:

What does the statement about over-counts in capabilities mean?

ANSWER:

The statements, such as: Where persons are members of multiple personnel classes, then the personnel capability information presented by personnel class should be used carefully because of possible double counts, and personnel resources should be managed at the instance level, are given because when a property is used to show overlapping subsets of a capability, then the same capability may be double scheduled unless this situation is recognized. Figure D-2 shows an example where a property of ReactorType presents how many reactors are available. The total amount of capability is 5, but the sum of all reactors subsets is 6, because 1 reactor can be qualified as a heating and a mixing type. In this situation the mixing and heating resources should be scheduled at the instance level in order not to overuse the available resources.

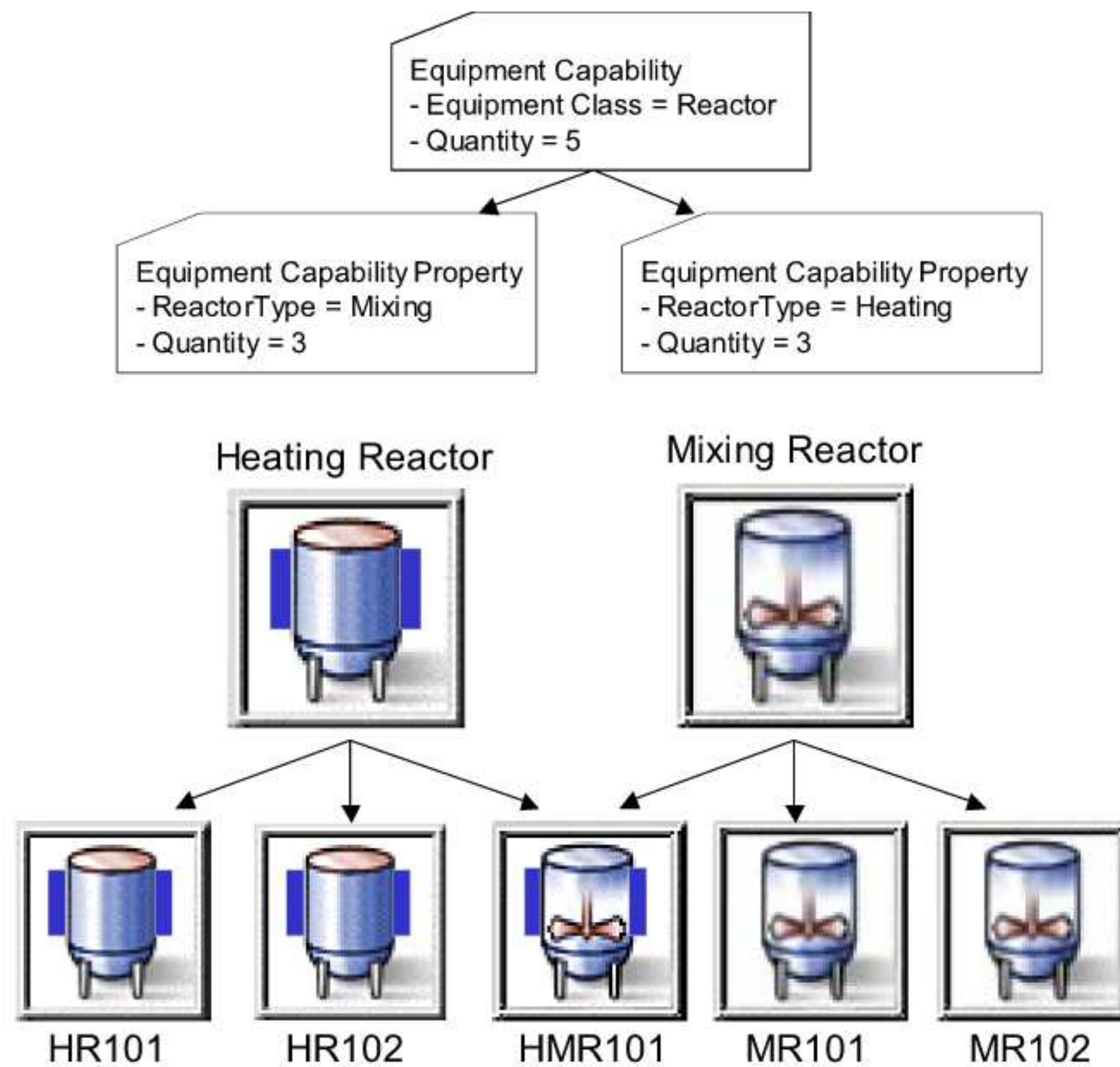


Figure D-2 — A property defining overlapping subsets of the capability

D.8 Routing and process capability

QUESTION:

How are routing information and processing capabilities represented in the models?

ANSWER:

Routing information can be represented in product segment dependencies, in process segment dependencies, or in both.

In some industries the routing is product specific, such as the route shown in Figure D-3. The left side of the figure illustrates the assembly of a specific electronic product, with multiple assembly operations (at G and H). The routing, for a single product (or class of products), is represented by the *product segment dependencies* illustrated in the center of Figure D-3. The capability of the system, for a specific product, can be represented in a set of *product segment dependencies*, as illustrated on the right side of Figure D-3.

In this example there could be multiple product routings given, one for each class of products. A scheduling system would use the product demand, product routing, and process segment capabilities to generate production schedules.

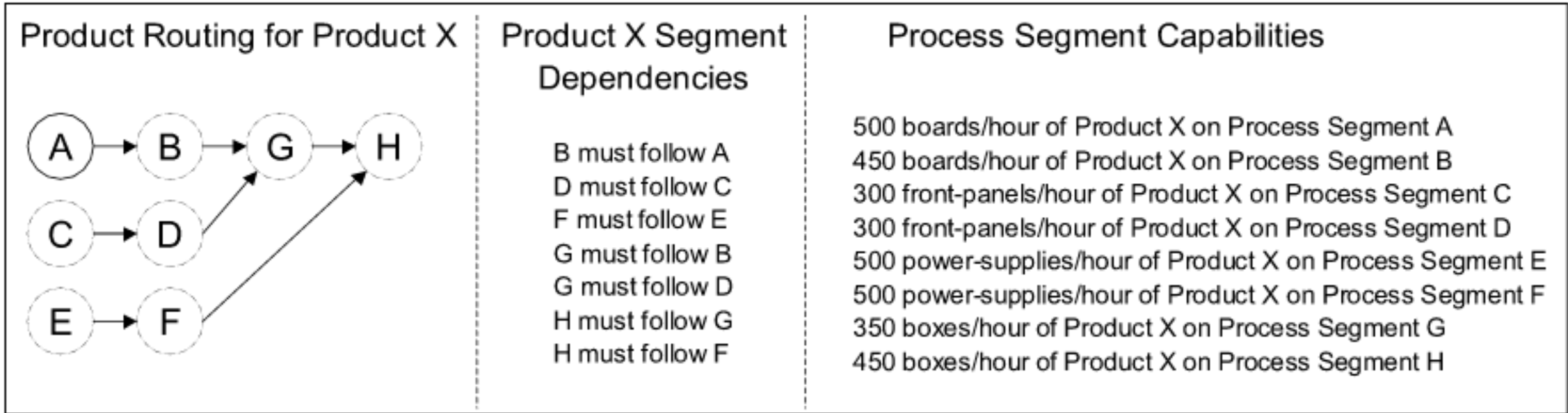


Figure D-3 — Routing for a product

In some industries, such as continuous production with byproducts, the routing may be dependent on the processes. In Figure D-4 the routing contains material dependencies information. The routing information is then used for scheduling. The route in the left side of Figure D-4 can be represented in a set of process segment definitions (center table in Figure D-4) and process segment dependency definitions (right table in Figure D-4). The process segment definitions contain the material production and consumption information. The consumption and production information within the process segments present additional constraints and dependencies required for scheduling of material B1, C1, and F1.

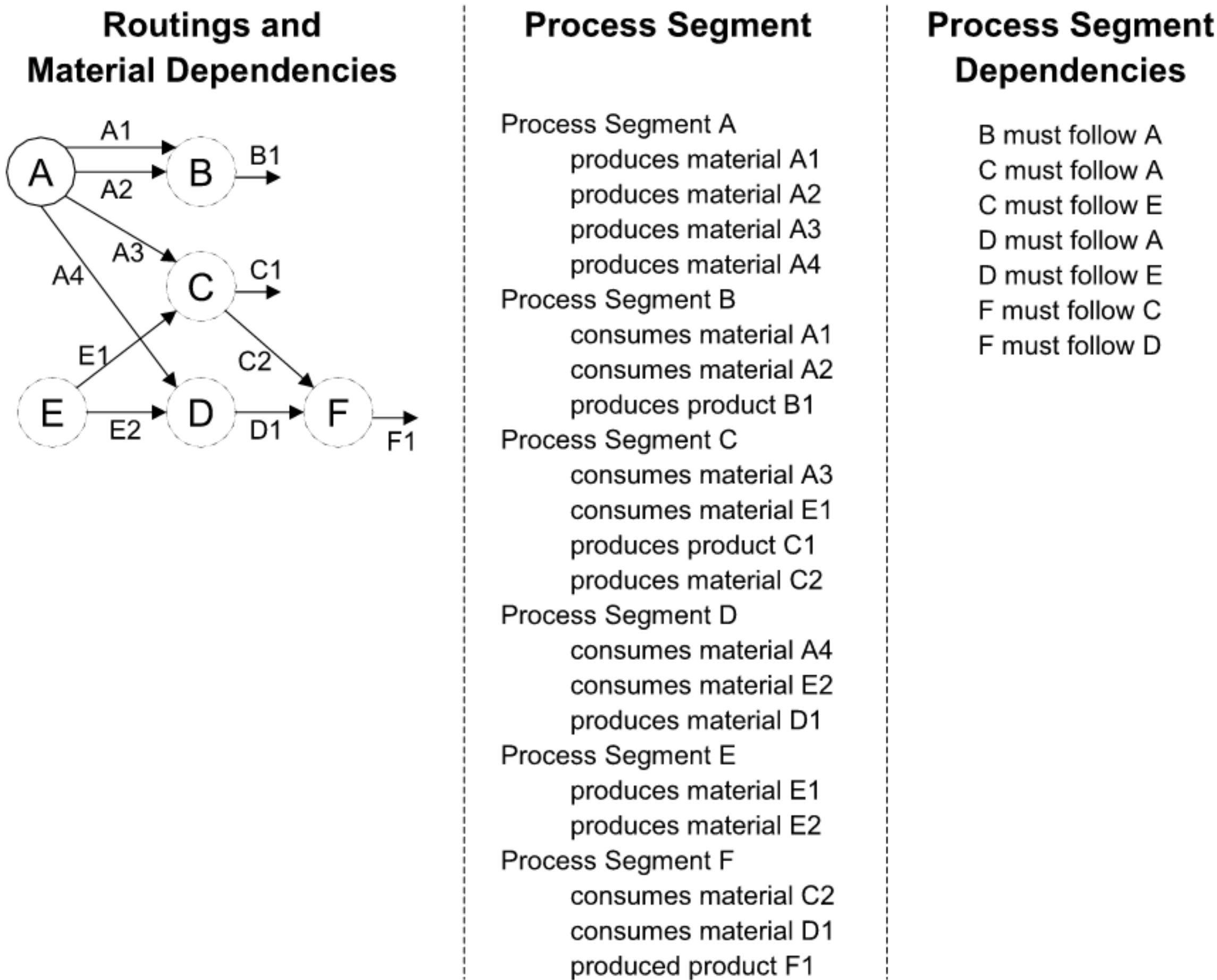


Figure D-4 — Routing with co-products and material dependencies

D.9 Product and process capability dependencies

QUESTION:

How is the information represented for complex scheduling problems, such as where there is a complex relationship between equipment and products? An example of this is a paint plant, where particular products can only be manufactured on specific equipment and yield varies based on product and equipment.

ANSWER:

There can be a mapping of equipment to *process segments*. The example shown in Figure D-5 shows sets of equipment A, B, C, and D that correspond to *process segments*. There might be multiple elements of equipment (process cells, production lines, production units) associated with each *process segment*, or it could correspond to a single piece of equipment.

In this example there can be specific rules for each product, or rules for classes of products. The *product segments* for each product would show which *process segments* are valid. The capability of each process segment and product combination can be represented in *process segment capability* objects. This information can then be used to fill in the information needed by a scheduling system, such as in a cost/throughput matrix illustrated in the lower right of Figure D-5. The costing information, and demand information required to determine the optimal throughput, do not cross the boundary addressed by this standard, but the capacity information does.

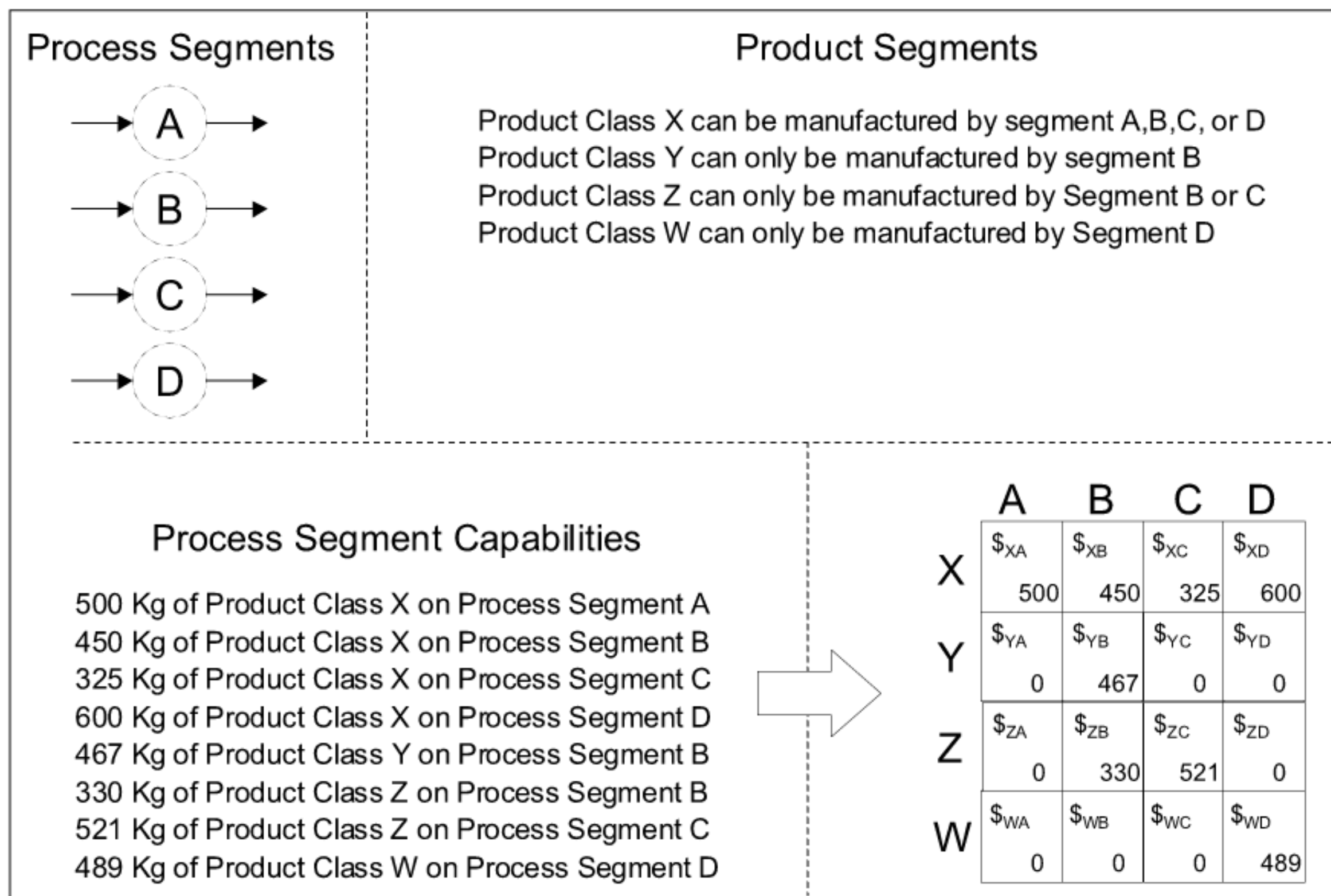


Figure D-5 — Product and process capability relationships

D.10 Representation of dependencies

QUESTION:

How are process or product dependencies represented?

ANSWER:

The *dependency type* attribute in the *process segment dependency* and the *product segment dependency* objects may be used to show the dependency. These may be simple dependencies, such as:

- a) One segment follows another segment.
- b) One segment cannot follow another segment.
- c) Two segments may run in parallel.
- d) One segment starts when another segment starts.
- e) One segment starts when another segment ends.
- f) One segment starts any time after another segment starts.
- g) One segment starts any time after another segment ends.

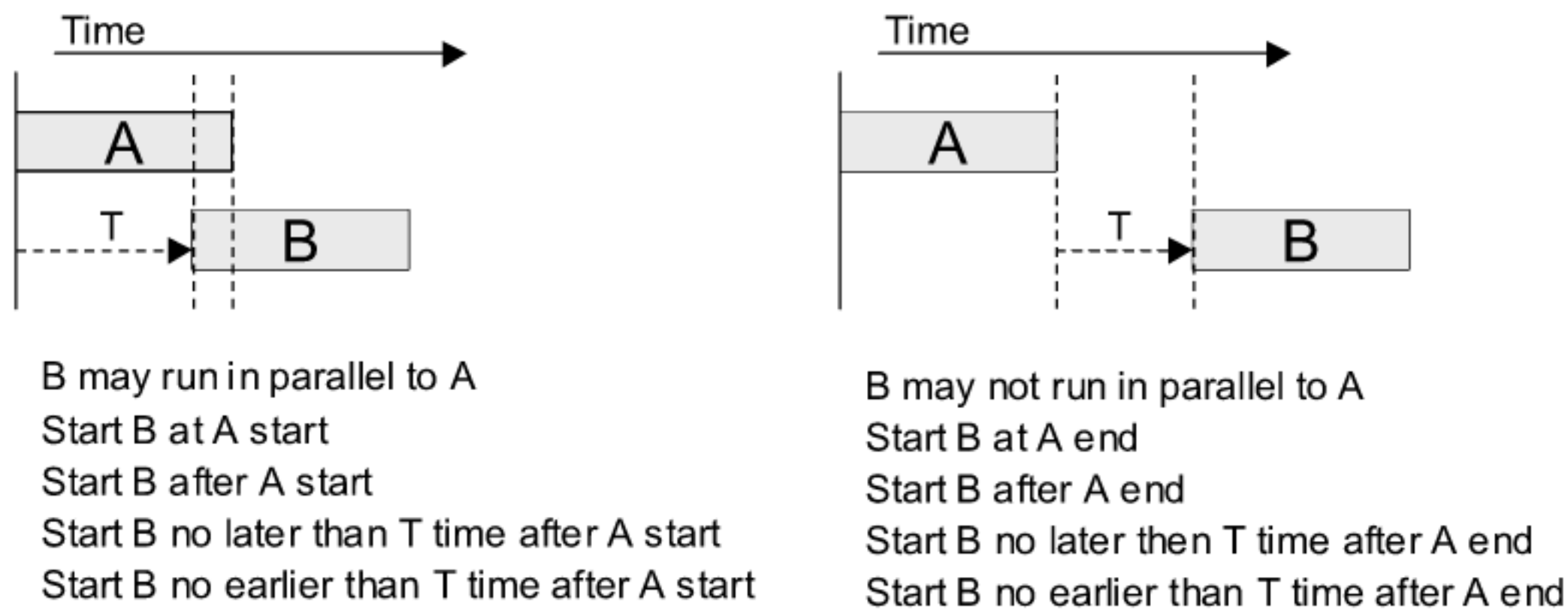
These dependencies may include physical constraints (because of production line layout), or constraints based on safety (such as prohibiting a “water add” after an “acid fill”), or constraints based on the chemical or physical processing required to make a product (bicycle wheels must be assembled before the bicycle final assembly).

More complicated constraints based on timing or other dependencies may also be defined using the *dependency factor* attribute.

EXAMPLE 1 The longer a semiconductor wafer is kept unprocessed the more defects are introduced, so there is a maximum delay allowed between segments of production.

EXAMPLE 2 A material (like cheese or wine) must age between processing segments so there is a minimum time allowed between segments of production.

Figure D-6 illustrates some of the possible dependencies using timing constraints associated with *product segment dependencies* or *process segment dependencies*. The left side of Figure D-6 illustrates possible dependencies where overlapped execution of the segment is allowed or required. The right side of Figure D-6 illustrates dependencies where non-overlapped execution is allowed or required.

**Figure D-6 — Time-based dependencies**

The dependency type may not only be related to time, but also to other unit of measures. For example, in Discrete Industry it may be common to specify a dependency between two work task segments that is based on the amount of product produced rather than on the time elapsed. The idea is to be able to express a dependency like “Start B after A has started and at least 50% of product quantity has been produced.”

D.11 Representation of material produced and consumed

QUESTION:

Why are there two different models for representing the material produced and material consumed, as attributes in some objects (production capability model and product definition model), and as separate objects in the production schedule and production performance models?

ANSWER:

In the production schedule and production performance model, typical implementations had used these as separate objects, and this information was of major importance. In the other models the material information usually refers to material consumed, and only rarely seems to be used to represent produced material. The attribute model was used in these cases so that the object models would be less complex.

D.12 Material produced and the capability model

QUESTION:

Why is there a *material produced* type in the capability model?

ANSWER:

In some processes, there are materials that are produced as a side effect of production, such as wastewater, or recycled materials. These materials may be used in other parts of production, and their availability may have to be considered in schedules.

D.13 How a material transfer is handled

QUESTION:

How is a material transfer handled? It is not a request for production, just a request to move material from one location to another.

ANSWER:

A material transfer can be handled using the production schedule and production performance models. There are multiple methods; one is to have a process segment defined for a "TRANSFER." The material to be transferred could be identified in the *material consumed requirement* object. The actual amount of material transferred could be identified in a *material produced actual* object. In some processes the two amounts may differ due to losses during transfer. The material locations for the movements could be identified in the material consumed subplot and material produced subplot information.

If the movement of material is initiated from the manufacturing operations level but must be known by the logistics level, then a production response could be generated that defined a "TRANSFER" segment. There is no requirement in this standard that there must be a production request for a production response, but corresponding business processes must support the exchange of information.

D.14 How to extend the standard when properties cannot be used

Properties are the standard method for extensions, however, where required information cannot be added using the property model, additional information, including industry- and application-specific information, may have to be added as non-standard attributes and objects. However, in order to achieve integration, these extensions have to be documented and explicitly shared among interoperating partners. A documentation method should be to define a new industry or application specific standard, referencing this Part and documenting the extensions.

D.15 Modeling of tools

QUESTION:

Are tools modeled as equipment or materials?

ANSWER:

Depending on the purpose of the tool, a tool can be modelled as either equipment or as materials. Tools may be used in different ways, for example tools used in the process of manufacturing versus tools included in the assembly of the product. Tools that can be consumed or must be lot traceable would be modelled as material. Other tools could be modelled as equipment. Some examples:

Equipment	Material
Electric drill	Bit
Sanding machine	Sandpaper
Screw driver	Screw
Hammer	Nail

D.16 What is equipment and what is a physical asset

QUESTION:

Does there need to be a one-to-one relationship between physical asset and equipment?

ANSWER:

There are cases of one-to-one relationships, and one-to-many relationships in each direction. One item that is scheduled as a single piece of equipment may be tracked as multiple physical assets for maintenance purposes. Likewise a single physical asset may be scheduled as multiple pieces of equipment. The relationship with these many to many roles is accomplished using the mapping of the role based equipment hierarchy to the physical asset hierarchy. One element in the equipment role hierarchy is a collection of assets in the physical asset hierarchy.

Equipment	Physical Asset	Relationship
TT-101 (temperature sensor)	1212-RTD-R21 (temperature probe)	1 to 1
P-1000 (palletizer)	Robot Labeller Bar code verifier / scanner Conveyer Servo Motor	1 to 4
CP-1001 (Capper) F-1001 (Sanitary Filter)	453212-121-09FEB2006 (capper machine)	2 to 1

D.17 How should dependencies in the production/operations schedule and production/operations response be handled

QUESTION:

How should dependencies in the production/operations schedule and production/operations response be handled?

ANSWER:

There are different types of dependencies (resource availability, customer priority, process dependency, and other)

Real applications need to model different types of dependencies between production/operations requests.

For example, an MRP/ERP at level 4 can generate separate requests for subassemblies or a single request for the final assembly of a given finished product and for the manufacturing of the intermediate materials that are the subassemblies to be assembled. Of course, there is a work process dependency relationship and final assembly may start only after all subassemblies have been manufactured. This is handled in an implementation where a production or work request states the start time and/or end time and then the associated segment requests specify the earliest start time, latest end time and duration for each segment. The algorithm for the actual dispatching of work can be implemented at level 4 or level 3, but represented in the production schedule or production/operations schedule request.

D.18 How are “mixed” operations types used

QUESTION:

How are “mixed” operations types to be used?

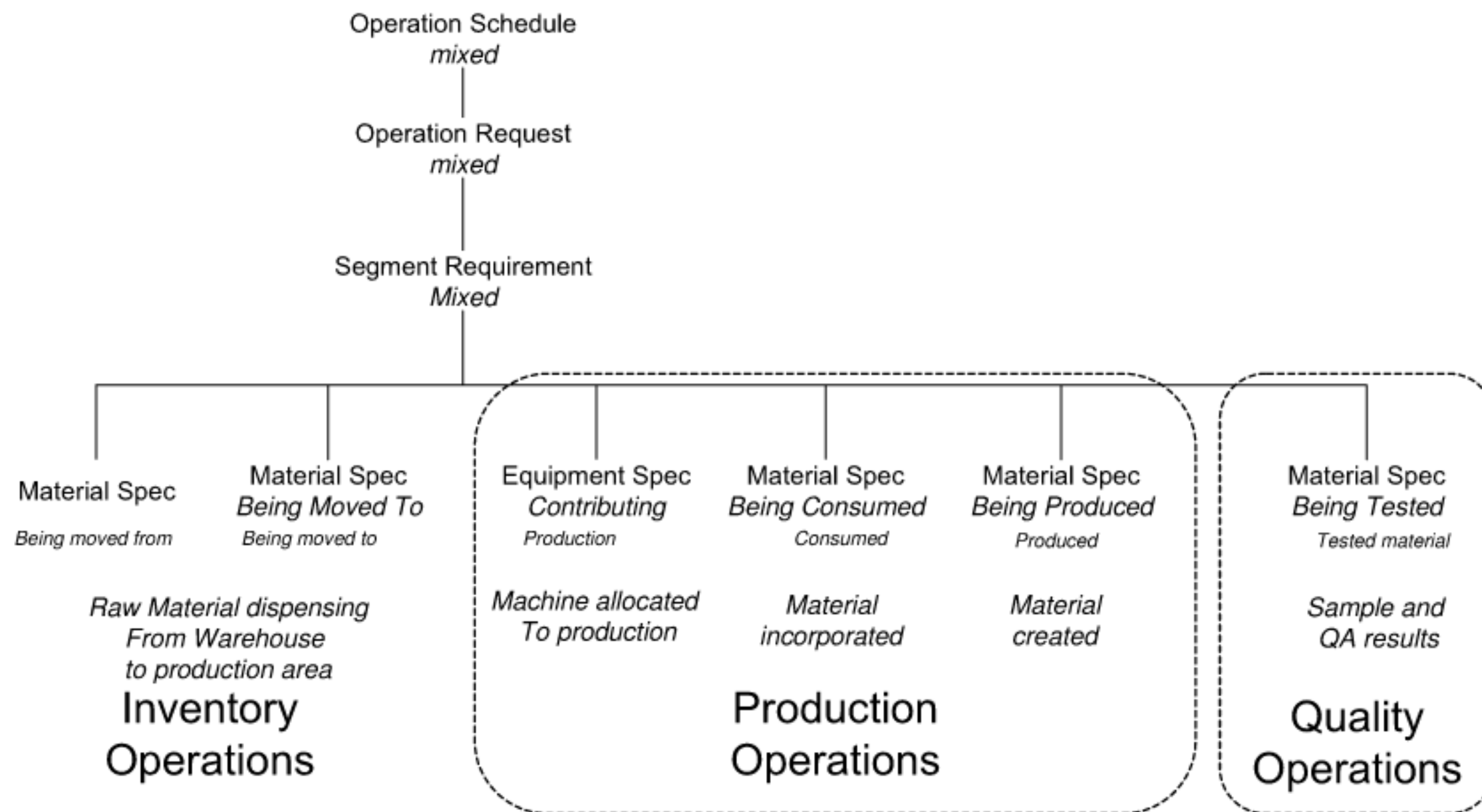
ANSWER:

The operation schedule model can handle mixed types of operations. The operation schedule, operation request and segment requirement can be specialized or mixed:

- A “mixed” operation schedule can hold mixed or specialized operation requests.
- A “mixed” operation request can hold mixed or specialized segment requirements.
- A “mixed” segment requirement can handle multiple resource specifications that would normally appear in specialized segment.

In the figure, the segment requirement specifies

- the material movements needed to fulfill the corresponding operation (inventory operation category);
- the resources for the production; the material information should include the dispensed material and other material those transfer would not need to be specified (liquid substance available from fixed pipes);
- the quality related resources that are involved during or at the end of the production operation.



D.19 What is the relationship between this standard and WBF's B2MML

QUESTION:

What is the relationship between this standard and WBF's B2MML?

ANSWER:

B2MML is an implementation of the standard that is based on XML technology and was developed by and is the property of WBF (ref: www.wbf.org). B2MML includes a compliance statement (as defined in Clause 9.)

The B2MML implementation includes additional information (elements) than are defined in this standard, usually for consistency of type definitions or to make use of the implementation easier when using standard programming languages.

B2MML is not the only way to implement this standard, but B2MML may be used as a reference implementation of the standard.

The committee developing the B2MML standard also sends comments on this standard to the committee developing this standard.

D.20 Unique objects

QUESTION:

There appears to be common attributes, structure and usage to the objects QualificationTestSpecification (Personnel), EquipmentCapabilityTestSpecification (Role based Equipment), PhysicalAssetCapabilityTestSpecification (Asset), and QAMaterialTestSpecification (Material). Why have these objects been presented as unique entities rather than utilizing a common "resource" test specification?

ANSWER:

The standard presents each of these objects with a unique namespace to clarify to the reader of the standard that these objects represent specific tests and test results, dependent on the context of usage within each resource model. Representing the models in this way clearly conveys to the reader the purpose and usage of each of the models within the standard.

Modern data modeling tools can yield multiple levels of optimization; however, these abstracted data models are not helpful to convey an understanding of how this standard represents information in this specific problem space. The models have been developed along the lines of other standards, such as OAGIS and EDI standards, which have proven to be useful standards for similar reasons.

While the committee members recognize that the models may be represented with a more optimized view, the purpose of this standard is not to present the most optimized data model. By further optimizing the data models represented in the standard, the committee feels that the meaning of these data models and their significance to the standard will be lost leading to misunderstandings or impractical implementations of the standard. The committee members also realize that implementations of this standard may employ advanced data modeling techniques that seek to optimize the representation of certain objects (i.e. using a common resource model in XML with an element to distinguish its type and maintain its unique namespace).

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Annex E

(Informative)

Logical information flows

E.1 Summary

The personnel model, equipment model, material model, and process segment model are collectively referred to as the resource models.

Systems communicating using the product capability, product definition, production schedule, and production performance models have to agree on the meaning of data values.

EXAMPLE Property IDs.

The objects in the resource models document the agreed upon values.

The assumption is that the resource model information is shared among communicating systems. The resource model information may be embedded as part of an information flow for other objects, may be exchanged as separate objects, or may be part of a common or distributed data store.

The Part 1 object model does not assume a one-to-one relationship between enterprise systems and manufacturing control systems. These may be one-to-many, many-to-one, or many-to-many relationships.

EXAMPLE Examples of the exchanges include contract manufacturing being performed for multiple customers (many-to-one), and a single company with multiple different manufacturing control systems (one-to-many).

Figure E-1 illustrates some possible logical information flows between enterprise systems and manufacturing control systems.

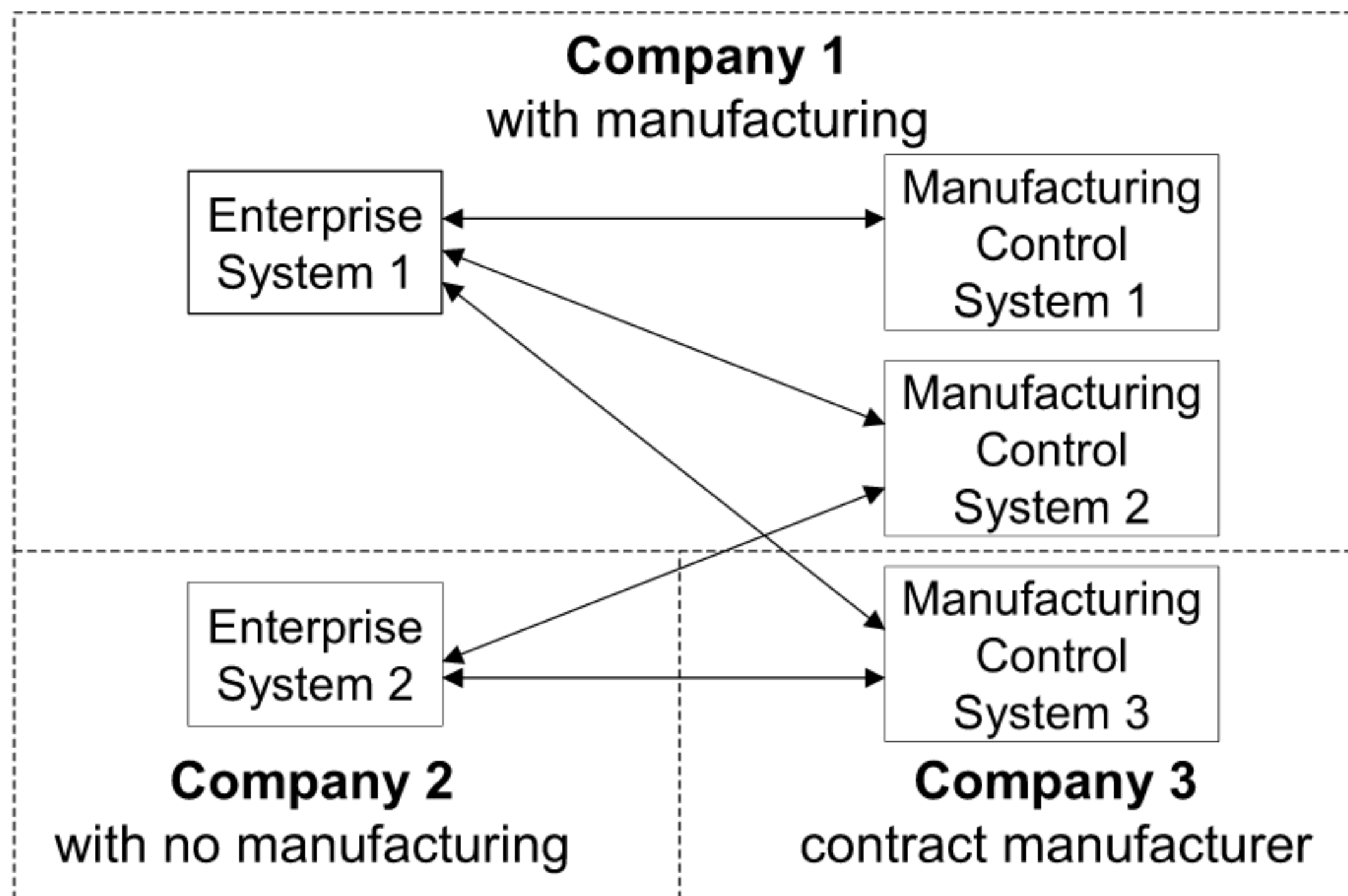


Figure E-1 — Enterprise to manufacturing system logical information flows

The information in this Part 2 standard is independent of any communication protocol. Part 2 makes no assumptions about the agents that create the information and the agents that use the information. Different implementations of the information model may describe different communication protocols and will often require additional attributes and objects.

EXAMPLE An SQL implementation will have to identify primary keys and may identify index attributes.

Additionally, the information model does not assume a one-to-one relationship between external systems and manufacturing control systems. There may be one-to-many, many-to-one, or many-to-many relationships.

EXAMPLE Examples of the many-to-many exchanges include multiple maintenance systems or quality systems.

Figure E-2 illustrates examples of manufacturing control system connections.

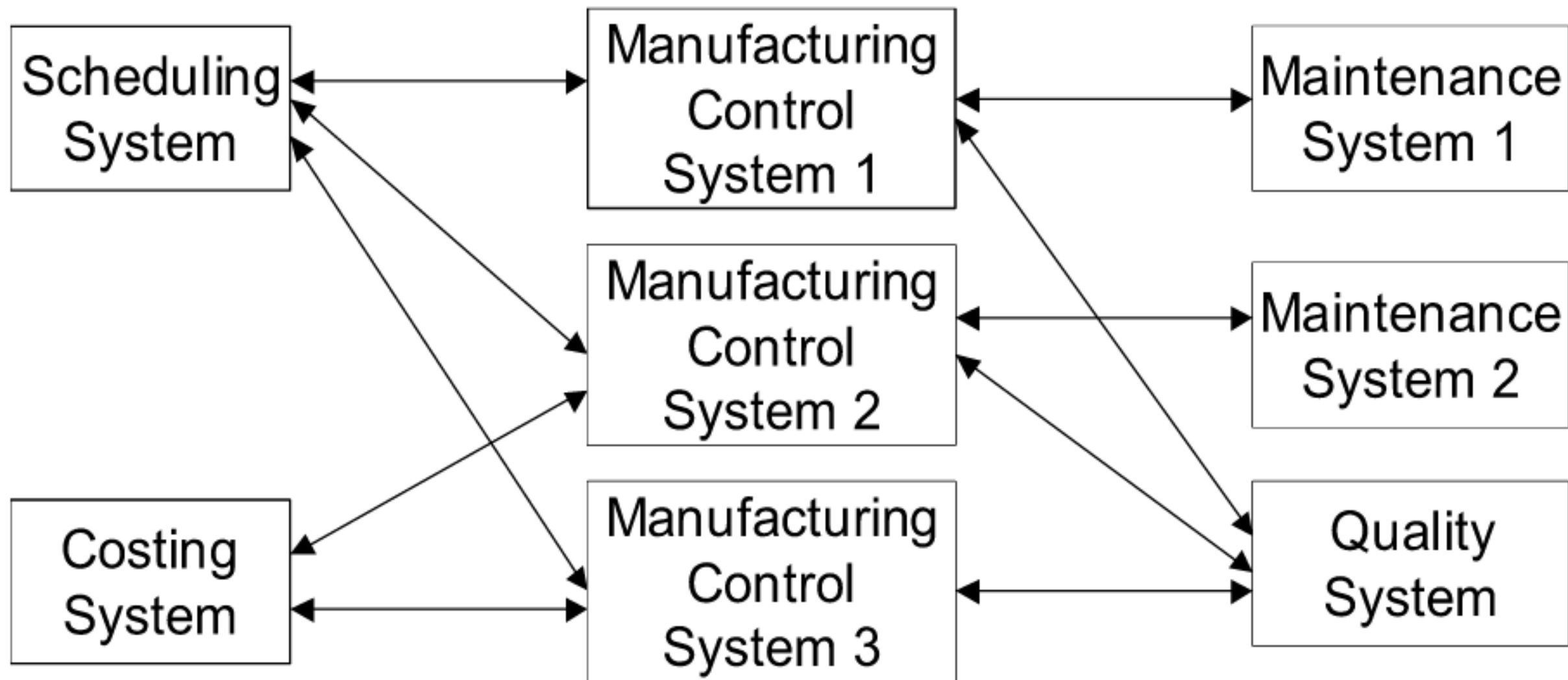


Figure E-2 — Logical information flows among multiple systems

Bibliography

MIMOSA OSA-EAI CCOM V3.2 – www.mimosa.org

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