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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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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-95.00.01-2000, 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 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.

The scope of this Part 2 standard is limited to the definition of the Part 1 object model attributes.

This Part 2 standard is structured to follow IEC guidelines. Therefore, the first three clauses present the *scope* of the standard, *normative references*, and *definitions*, in that order.

Clause 4 is normative. The intent is to describe the attributes associated with the objects defined in Part 1.

Clause 5 is normative. It defines completeness, conformance and compliance criteria associated with the objects defined in Part 1 and the attributes defined in Part 2.

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

Annex B is informative. It illustrates how the models could be used in different circumstances.

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

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Introduction

This Part 2 standard further defines the object models described in ANSI/ISA-95.00.01-2000, Enterprise-Control System Integration Part 1: Models and Terminology (hereafter referred to as Part 1) by adding attribute definitions and examples. The models and terminology defined in Part 1 and Part 2

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, the Part 1 and Part 2 standards 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.

The Part 1 and Part 2 standards 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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1 Scope

This Part 2 standard, in conjunction with ANSI/ISA-95.00.01-2000, Enterprise-Control System Integration Part 1: Models and Terminology, defines the interface content between manufacturing control functions and other enterprise functions. The interfaces considered are the interfaces between levels 3 and 4 of the hierarchical model defined by Part 1 and Part 2. The goal is to reduce the risk, cost, and errors associated with implementing these interfaces.

The scope of Part 2 is limited to the definition of attributes for the Part 1 object models.

This Part 2 standard does not define attributes to represent the object relationships defined in Part 1.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of the IEC and ISO maintain registers of currently valid normative documents.

a) ANSI/ISA-95.00.01-2000, Enterprise-Control System Integration Part 1: Models and Terminology

b) IEC 61512-1:1997, Batch control – Part 1: Models and terminology

c) ANSI/ISA-88.01-1995, Batch Control Part 1: Models and Terminology

d) ENV 40003:1991, Computer Integrated Manufacturing (CIM); Systems Architecture; Framework for Enterprise Modeling

e) ENV 12204:1996, Advanced Manufacturing Technology; Systems Architecture; Constructs for Enterprise Modeling

f) ISO 14258:1998, Concepts and Rules for Enterprise Models

g) ISO 15704:2000, Industrial Automation Systems--Requirements for Enterprise--Reference Architectures and Methodologies

3 Definitions

For the purposes of this standard, the following definition applies. Other terms used in this Part 2 standard are defined in Part 1.

3.1 process segment:
a view of a collection of resources needed for a segment of production, independent of any particular product at the level of detail required to support business processes that may also be independent of any particular product. This may include material, energy, personnel, or equipment.

4 Object model attributes

4.1 Introduction

This clause defines the attributes associated with the objects defined in the Part 1 standard.

Tables 2 through 87 in clause 4 define the attributes for objects defined in the Part 1 standard, clause 7. The attributes are an extension to the object information model defined in the Part 1 standard and thus are part of the definition of terms. The attributes of this Part 2 standard and the object models of Part 1 define interfaces for enterprise-control system integration.

A minimum set of industry-independent information has been defined, in this Part 2 standard, as attributes. However, values for all attributes may not be required depending of the actual usage of the models. If additional information, including industry- and application-specific information, is needed, it shall be represented as properties. This solution increases the usability through the use of standard attributes, and allows flexibility and extensibility through the use of properties. This was done to make the standard as widely applicable as possible.

4.2 Explanation of tables

This subclause defines the meaning of the attribute tables. This includes a definition of the object identification, data types, and definition of the examples in the tables.

4.2.1 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 translation of the IDs of the exchanged information from a system's internal identification. For example, a unit may be identified as resource "R100011" in the scheduling system and "East Side Reactor" in the manufacturing system. A unique identification set shall be agreed to in order to exchange information.

The object IDs are defined 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.

4.2.2 Data types

The attributes defined are abstract representations, without any specific data type defined. A specific implementation will define how the information is represented. For example,

a) an attribute may be represented as a string in one implementation and as a numeric value in another implementation;

b) a date/time value may be represented in ISO standard format in one implementation and in Julian calendar format in another; or

c) a relationship may be represented by two fields (type and key) in data base tables or by a specific tag in XML.

4.2.3 Definition of examples

Examples are included with each attribute definition. Where multiple examples are used, there are multiple rows in the right hand column. See Table 1 below for how the example rows and columns are used.

Table 1 — Table example

Attribute Name	Description	Examples
Name of first attribute	Description of first attribute	Example #1 for first attribute
		Example #2 for first attribute
		Example #3 for first attribute
Name of second attribute	Description of second attribute	Example #1 for second attribute
		Example #2 for second attribute
		Example #3 for second attribute
Name of third attribute	Description of third attribute	Example #1 for third attribute
		Example #2 for third attribute
		Example #3 for third attribute

When an example value is a set of values, or a member of a set of values, the set of values is defined 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.

4.2.4 Data relationships

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 Part 1 object model figures. This relationship is not conformant to the Unified Modeling Language (UML) modeling methodology, but was done to keep the diagrams simpler. Figure 1 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 was not meant to describe implementations. This applies to the following models:

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

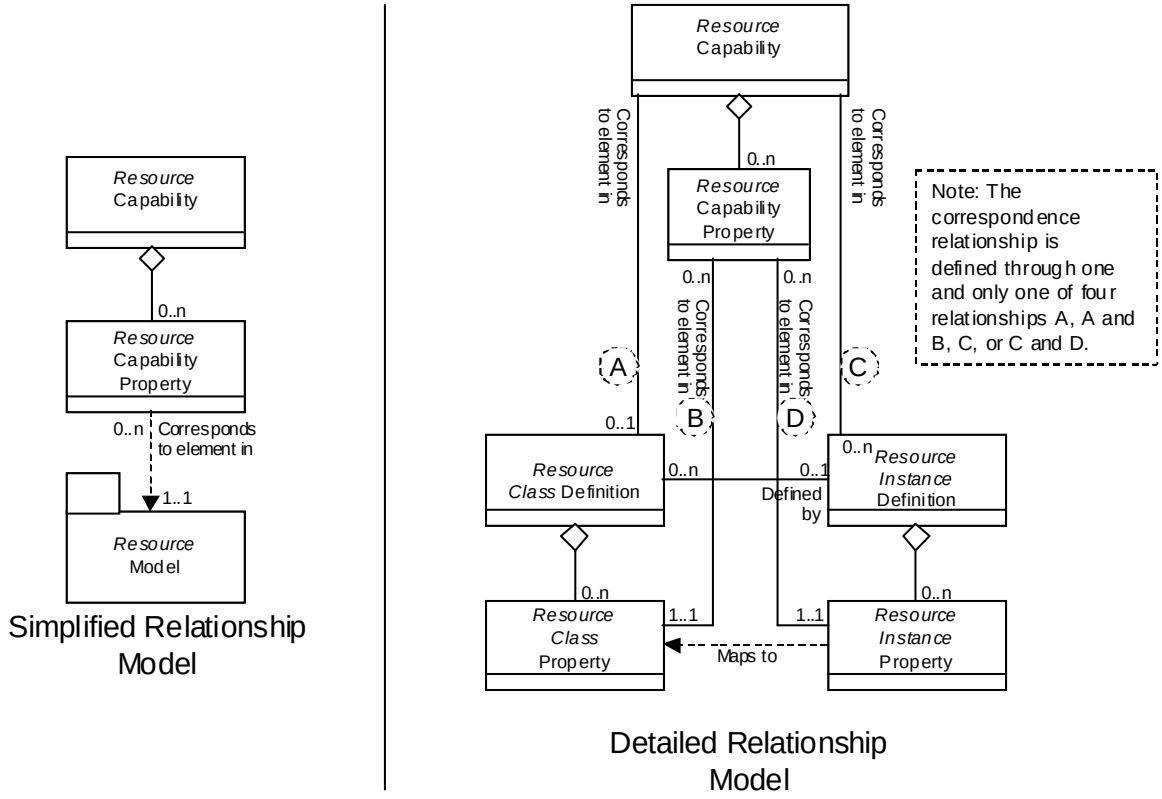


Figure 1 — Detailed relationship models

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

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

4.3 Production capability model

Figure 2 is a copy of Figure 15 in Part 1, with a clarification of the relationship to the personnel, equipment, and material models.

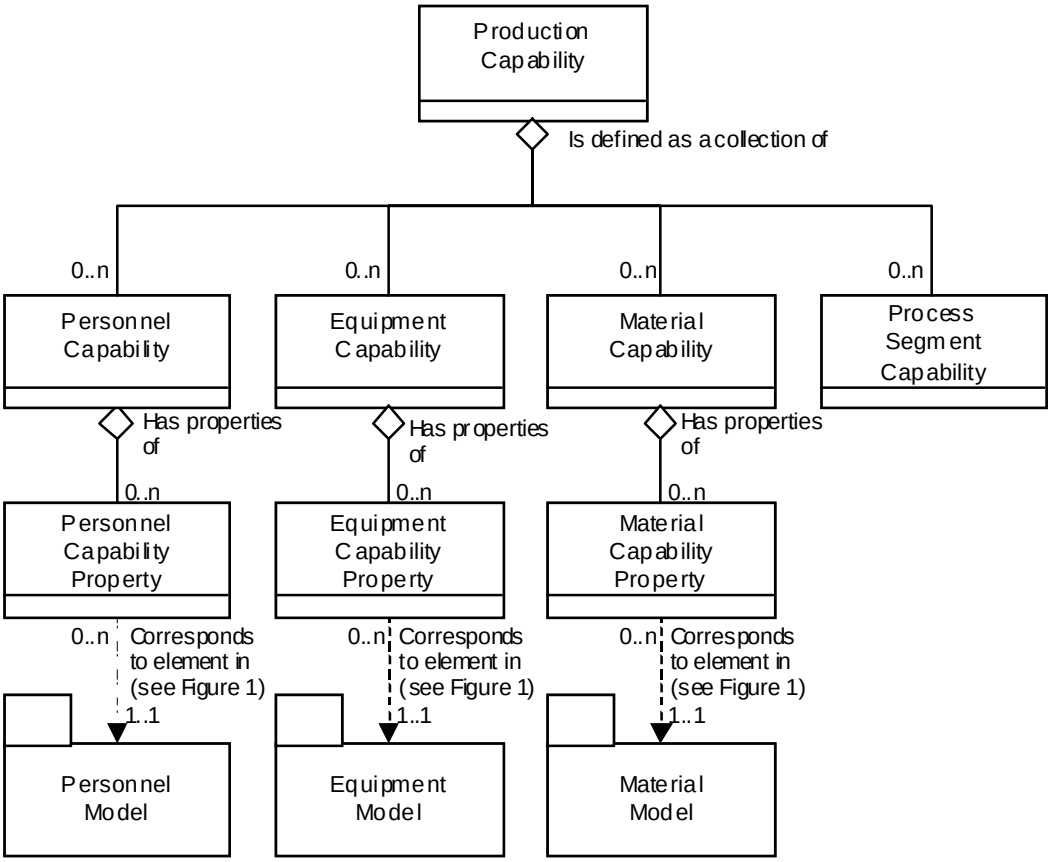


Figure 2 — Production capability model

4.3.1 Production capability

Table 2 defines the attributes for *production capability* objects.

Table 2 — Production capability attributes

Attribute Name	Description	Examples
ID	Defines a unique instance of a production capability for a specified element of the equipment hierarchy model [Part 1 Section 5.2] (*enterprise, site, area, process cell, production line, or production unit*).	1999/12/30-HPC52
		1999/12/30-HPC52.01
		1999/12/30-HPC52.01.02
Description	Contains additional information and descriptions of the *production capability* definition.	“One day’s production capability for the Boston Widget Company.”
		“One day’s production capability for the South Shore Production Plant.”
		“One day’s production capability for the East Wing manufacturing line.”
Capability Type	The capability type: Available, Unattainable, or Committed.	Available
		Unattainable
		Committed
Reason	Defines the reason for the capability type. For example, if committed, then committed for production or for maintenance; or if unavailable, then the reason for the unavailability.	Available for Production
		Due to Power Outage
		Available for Maintenance
Location	An identification of the associated element of the equipment hierarchy model. Zero or more as required to identify the specific scope of the production capability definition.	Boston Widget Company
		South Shore Production Plant
		East Wing Manufacturing Line #2
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Enterprise
		Site
		Production line
Start Time	The starting date and time of the production capability.	1999-12-29 11:59
		1999-12-30 11:59
		1999-12-31 11:59
End Time	The ending date and time of the production capability.	1999-12-30 12:00
		1999-12-31 12:00
		2000-01-01 12:00
Published Date	The date and time on which the *production capability* was published or generated.	1999-11-03 13:55
		1999-11-03 13:55
		1999-11-03 13:55

4.3.2 Personnel capability

Table 3 defines the attributes for *personnel capability* objects.

Table 3 — Personnel capability attributes

Attribute Name	Description	Example
Personnel Class	Identifies the associated *personnel class* of the capability.	Widget Assembly Machine Operator
Person	Identifies the associated *person* of the capability.	SSN 999-55-1212
Description	Contains additional information and descriptions of the *personnel capability* definition.	"Widget machine operator availability over the 2000 New Year boundary"
Capability Type	The capability type: Available, Unattainable, or Committed.	Available
Reason	Defines the reason for the capability type.	Available for Production
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	South Shore Production Plant
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Site
Start Time	The starting time associated with the *personnel capability.* If omitted, then the capability is associated to the parent *production capability* start time.	1999-12-30 11:59
End Time	The ending time associated with the *personnel capability.* If omitted, then the capability is associated to the parent *production capability* end time.	2000-01-01 12:00
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	48
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours

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.

4.3.3 Personnel capability property

Table 4 defines the attributes for *personnel capability property* objects.

Table 4 — Personnel capability property attributes

Attribute Name	Description	Examples
Property Name	An identification of a property of the associated *person property* or *personnel class property*.	Operator Level
		Packing Machine Certified
Description	Contains additional information and descriptions of the *personnel capability property* definition.	“Level of operator certification”
		“Level of packing machine operator certification”
Value	The value, set of values, or range of the property.	Apprentice
		Journeyman
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
		[not applicable]
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	1
		16
Quantity Unit of Measure	The unit of measure of the associated quantity.	Days
		Hours

4.3.4 Equipment capability

Table 5 defines the attributes for *equipment capability* objects.

Table 5 — Equipment capability attributes

Attribute Name	Description	Examples
Equipment Class	Identifies the associated *equipment class* of the capability.	Widget Jig
		Widget Lathe
Equipment	Identifies the associated *equipment* of the capability.	Reactor 101
		Lathe machine 15
Description	Contains additional information and descriptions of the *equipment capability* definition.	"Widget Jig commitment over the 2000 New Year boundary"
		"Widget Lathe availability over the 2000 New Year boundary"
Capability Type	The capability type: Available, Unattainable, or Committed.	Committed
		Unattainable
Reason	Defines the reason for the capability type.	Available for Production
		Due to Y2K Noncompliance
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	South Shore Production Plant
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Site
Start Time	The starting time associated with the *equipment capability.* If omitted, then the capability is associated to the parent *production capability* start time.	1999-12-30 11:59
		1999-12-30 11:59
End Time	The ending time associated with the *equipment capability.* If omitted, then the capability is associated to the parent *production capability* end time.	2000-01-01 12:00
		2000-01-01 12:00
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	48
		2
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours
		Days

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.

4.3.5 Equipment capability property

Table 6 defines the attributes for *equipment capability property* objects.

Table 6 — Equipment capability property attributes

Attribute Name	Description	Examples
Property Name	An identification of a property of the associated *equipment property* or *equipment class property*.	Heating Capability
		Volume
Description	Contains additional information and descriptions of the *equipment capability property* definition.	“Measure of the heating capability”
		“Measure of the equipment volume”
Value	The value, set of values, or range of the property.	500
		10000
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	BTU/Hour
		Liters
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	2
		12
Quantity Unit of Measure	The unit of measure of the associated quantity.	Days
		Hours

4.3.6 Material capability

Table 7 defines the attributes for *material capability* objects.

Table 7 — Material capability attributes

Attribute Name	Description	Examples
Material Class	Identifies the associated *material class* of the capability.*	Polymer sheet stock 1001A
		Lubricant Oil
Material Definition	Identifies the associated *material definition* of the capability.*	Sheet stock 1443a
		Lube Oil 8999
Material Lot	Identifies the associated *material lot* of the capability.*	1443a5mm
		8999LU-5G
Material Sublot	Identifies the associated *material sublot* of the capability.*	1443a5mm-SL1
		8999LU-5G-SL15
Description	Contains additional information and descriptions of the *material capability* definition.	“Polymer sheet stock commitment”
		“Lubricant oil commitment over the 2000 New Year boundary”
Capability Type	The capability type: Available, Unattainable, or Committed.	Committed
		Committed
Reason	Defines the reason for the capability type.	Available for Production
		Available for Production
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	South Shore Production Plant
		Production Line 15
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Site
		Production Line
Material Use	Defines the material use: Material Consumed, Material Produced, or Consumable	Material Consumed
		Material Consumed
Start Time	The starting time associated with the *material capability.* If omitted, then the capability is associated to the parent *production capability* start time.	1999-12-30 11:59
		1999-12-30 11:59
End Time	The ending time associated with the *material capability.* If omitted, then the capability is associated to the parent *production capability* end time.	2000-01-01 12:00
		2000-01-01 12:00
Quantity	Specifies the quantity of the material capability defined, if applicable.	2000
		155
Quantity Unit of Measure	The unit of measure of the material quantity, if applicable.	Sheets
		Liters

* Typically a *material class, material definition, material lot,* or *material sublot* 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.

4.3.7 Material capability property

Table 8 defines the attributes for *material capability property* objects.

Table 8 — Material capability property attributes

Attribute Name	Description	Examples
Property Name	An identification of a property of the associated *material property* or *equipment class property.*	Concentration
		pH
Description	Contains additional information and descriptions of the *material capability property* definition.	“Concentration of active ingredient”
		“pH of active ingredient”
Value	The value, set of values, or range of the property.	50
		6.3
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	%
		pH
Quantity	Specifies the quantity of the material capability defined, if applicable.	55
		2567
Quantity Unit of Measure	The unit of measure of the associated quantity.	mL
		kiloliters

4.4 Process segment capability model

Figure 3 is a copy of Figure 16 in Part 1, with a clarification of the relationship to *process segments*, and the personnel, equipment, and material models.

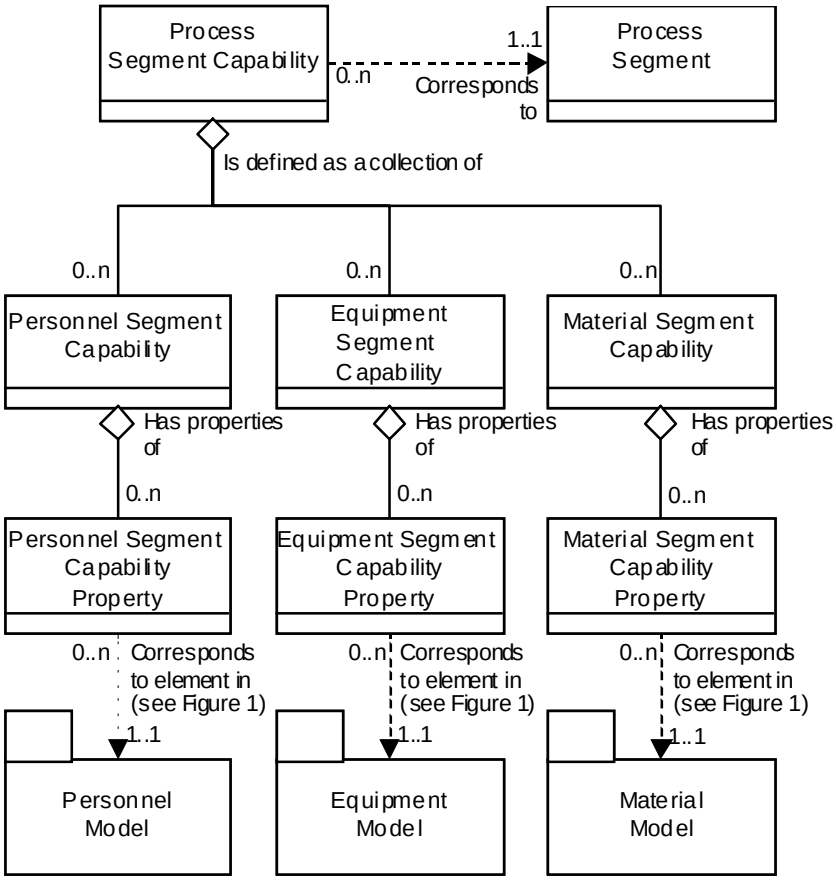


Figure 3 — Process segment capability

4.4.1 Process segment capability

Table 9 defines the attributes for *process segment capability* objects. *Process segment capability* has an equivalent structure to the personnel, equipment and material structure of *production capability*, except the *process segment capability* is defined for a specific *process segment*.

Table 9 — Process segment capability attributes

Attribute Name	Description	Example
ID	A unique identifier of the *process segment capability* within the scope of the parent *production capability*.	1000104
Description	Contains additional information and descriptions of the *process segment capability* definition.	“Defines the available capability for the Widget Assembly process segment”
Process Segment	Identifies the *process segment*.	Widget Assembly
Capability Type	The capability type: Available, Unattainable, or Committed.	Available
Reason	Defines the reason for the capability type.	Available for Production
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Production Line
Start Time	The starting time associated with the *process segment capability.* If omitted, then the capability is associated to the parent *production capability* start time.	1999-12-30 11:59
End Time	The ending time associated with the *process segment capability.* If omitted, then the capability is associated to the parent *production capability* end time.	2000-01-01 12:00

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

4.4.2 Segment personnel capability

Table 10 defines the attributes for *segment personnel capability* attributes.

Table 10 — Segment personnel capability attributes

Attribute Name	Description	Example
Personnel Class	Identifies the set of associated *personnel classes* of the capability.	Assembly Operator
Person	Identifies the set of associated *persons* of the capability.	SSN 999-55-1212
Description	Contains additional information and descriptions of the *segment personnel capability* definition.	Available personnel for the Widget Assembly operation
Capability Type	The capability type: Available, Unattainable, or Committed.	Available
Reason	Defines the reason for the capability type.	Available for Production
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Production Line
Start Time	The starting time associated with the *segment personnel capability.* If omitted, then the capability is associated with the parent *process segment capability* start time.	1999-12-30 11:59
End Time	The ending time associated with the *segment personnel capability.* If omitted, then the capability is associated with the parent *process segment capability* end time.	2000-01-01 12:00
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	48
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours

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.

4.4.3 Segment personnel capability property

Table 11 defines the attributes for *segment personnel capability property* objects.

Table 11 — Segment personnel capability property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *person property* or *personnel class property.*	Assembly Operators
Description	Contains additional information and descriptions of the *segment personnel capability property* definition.	“Number of assembly operators available for the Widget assembly operation.”
Value	The value, set of values, or range of the property.	Apprentice
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	<not applicable>
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	24
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours

4.4.4 Segment equipment capability

Table 12 defines the attributes for *segment equipment capability* objects.

Table 12 — Segment equipment capability attributes

Attribute Name	Description	Example
Equipment Class	Identifies the associated *equipment class* of the capability.	Widget Assembly Jig
Equipment	Identifies the associated *equipment* of the capability.	JIG 101
Description	Contains additional information and descriptions of the *segment equipment capability* definition.	“Committed assembly jigs for the Widget assembly operation.”
Capability Type	The capability type: Available, Unattainable, or Committed.	Committed
Reason	Defines the reason for the capability type.	Available for Production
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Production Line
Start Time	The starting time associated with the *segment equipment capability.* If omitted, then the capability is associated with the parent *process segment capability* start time.	1999-12-30 11:59
End Time	The ending time associated with the *segment equipment capability.* If omitted, then the capability is associated with the parent *process segment capability* end time.	2000-01-01 12:00
Quantity	Specifies the quantity of the equipment capability defined, if applicable.	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours

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.

4.4.5 Segment equipment capability property

Table 13 defines the attributes for *segment equipment capability property* attributes.

Table 13 — Segment equipment capability property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *equipment property* or *equipment class property*.	Jig Status
Description	Contains additional information and descriptions of the *segment equipment capability property* definition.	“Committed widgets per hour”
Value	The value, set of values, or range of the property.	Clean
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	{Clean, Dirty}
Quantity	Specifies the quantity of the personnel capability defined, if applicable.	1
Quantity Unit of Measure	The unit of measure of the associated quantity.	Hours

4.4.6 Segment material capability

Table 14 defines the attributes for *segment material capability* objects.

Table 14 — Segment material capability attributes

Attribute Name	Description	Example
Material Class	Identifies the associated *material class* of the capability. *	Rivet-10002
Material Definition	Identifies the associated *material definition* of the capability. *	General Purpose 2mm rivet
Material Lot	Identifies the associated *material lot* of the capability. *	L66272
Material Sublot	Identifies the associated *material sublot* of the capability. *	L66272-SL4
Description	Contains additional information and descriptions of the *segment material capability* definition.	Rivets Available for the Widget Assembly Operation
Capability Type	The capability type: Available, Unattainable, or Committed.	Available
Reason	Defines the reason for the capability type.	Available for Production
Location	An identification of the associated element of the equipment hierarchy model. If omitted, then the capability is associated to the parent *production capability* location. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15
Element Type	A definition of the type of associated element of the equipment hierarchy model.	Production Line
Material Use	Defines the material use: Material Consumed, Material Produced, or Consumable.	Material Consumed
Start Time	The starting time associated with the *segment material capability.* If omitted, then the capability is associated with the parent *process segment capability* Start Time.	1999-12-30 11:59
End Time	The ending time associated with the *segment material capability.* If omitted, then the capability is associated with the parent *process segment capability* End Time.	2000-01-01 12:00
Quantity	Specifies the quantity of the material capability defined, if applicable.	3000
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Pieces

* Typically either a *material class, material definition, material lot,* or *material sublot* 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.

4.4.7 Segment material capability property

Table 15 defines the attributes for *segment material capability property* objects.

Table 15 — Segment material capability property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *material property* or *equipment class property.*	Length
Description	Contains additional information and descriptions of the *segment material capability property* definition.	Length of rivet
Value	The value, set of values, or range of the property.	25.4
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm
Quantity	Specifies the quantity of the material capability defined, if applicable.	200
Quantity Unit of Measure	The unit of measure of the associated quantity.	Pieces

4.5 Personnel model

Figure 4 is a copy of Figure 17 in Part 1.

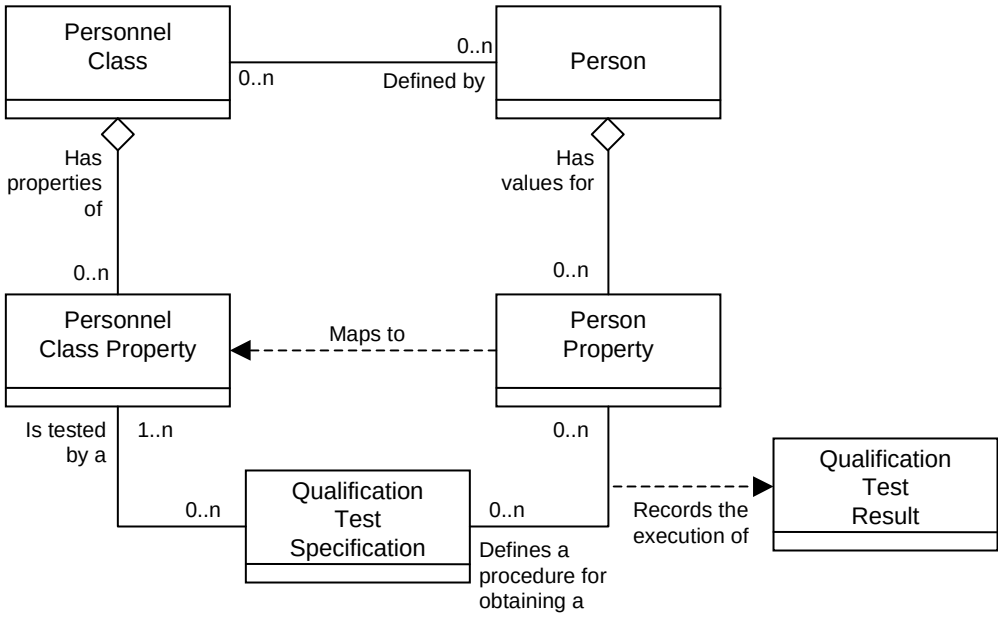


Figure 4 — Personnel model

4.5.1 Person

Table 16 defines the attributes for *person* objects.

Table 16 — Person attributes

Attribute Name	Description	Examples
ID	A unique identification of a specific person, within the scope of the information exchanged (*production capability, production schedule, production performance*, …) The ID shall be used in other parts of the model when the *person* needs to be identified, such as the *production capability* for this person, or a *production response* identifying the person.	999-123-4567
		Jane W Smith - #2
		Employee 23
Description	Additional information about the resource.	“Person Information”
		“Person Information”
		“Person Information”
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.	Joe Smith III
		Jane
		Bubba

4.5.2 Person property

Table 17 defines the attributes for *person property* objects.

Table 17 — Person property attributes

Attribute Name	Description	Examples
ID	An identification of the specific property.	Class 1 Certified
		Exposure Hours Available
		Pager Number
Description	Additional information about the *person property.*	“Indicates if the person is Class 1 certified widget assembly operator”
		“Indicates number of exposure hours available this month”
		“Pager number”
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 *personnel class property.*	True
		4
		800-555-1212
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Boolean
		Hours
		phone number

4.5.3 Personnel class

Table 18 defines the attributes for *personnel class* objects.

Table 18 — Personnel class attributes

Attribute Name	Description	Example
ID	A unique identification of a specific *personnel class*. These are not necessarily job titles, but identify classes that are referenced in other parts of the model.	Widget Assembly Operator
Description	Additional information and description about the *personnel class*.	“General information about widget assembly operators.”

4.5.4 Personnel class property

Table 19 defines the attributes for *personnel class property* objects.

Table 19 — Personnel class property attributes

Attribute Name	Description	Examples
ID	An identification of the specific property, unique under the scope of the parent *personnel class* object. For example, the property “*Has Class 1 Safety Training*” (with values of *Yes* or *No*) may be defined under several different *Personnel Class* definitions, such as *Fork Lift Operator* and *Pipe Fitter* classes, but has a different meaning for each class.	Class 1 Certified
		Night Shift Available
		Monthly Exposure Hours Maximum
Description	Additional information and description about the *personnel class property.*	“Indicates the certification level of the operator.”
		“Indicates if operator is available for night shift.”
		“Indicates the maximum monthly exposure hours that can be used.”
Value	The value, set of values, or range of the property. This defines a range of possible numeric values, a list of possible values, or it may be empty if any value is valid.	{True, False}
		{True, False}
		[0..20]
Value Unit of Measure	The unit of measure of the associated property values, if applicable.	Boolean
		Boolean
		hours

4.5.5 Qualification test specification

Table 20 defines the attributes for *qualification test specification* objects.

Table 20 — Qualification test specification attributes

Attribute Name	Description	Example
Name	An identification of a test for certifying one or more values for one or more *person properties*. For example, this may be the name of a document that describes or defines the qualification test.	Class 1 Widget Assembly Certification Test
Description	Additional information and description about the *qualification test specification.*	“Identifies the test for Class 1 Widget assembly certification –returns a True or False value for the *Class 1 widget assembly certification* property
Version	An identification of the version of the qualification test specification. In cases where there are multiple versions of a qualification test specification, then the version attribute shall contain the additional identification information to differentiate each version.	V23

4.5.6 Qualification test result

Table 21 defines the attributes for *qualification test result* objects.

Table 21 — Qualification test result attributes

Attribute Name	Description	Example
ID	A unique instance identification that records the results from the execution of a test identified in a *qualification test specification* for a specific *person*. (For example, this may just be a number assigned by the testing authority.)	T5568700827
Description	Additional information and description about the *qualification test result*s.	“Results from Joe’s widget assembly qualification test for October 1999.”
Date	The date and time of the qualification test.	1999-10-25 13:30
Result	The result of the qualification test. For example: Pass, Fail	Pass
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	[not applicable]
Expiration	The date of the expiration of the qualification.	2000-10-25 13:30

4.6 Equipment model

Figure 5 is a copy of Figure 18 in Part 1.

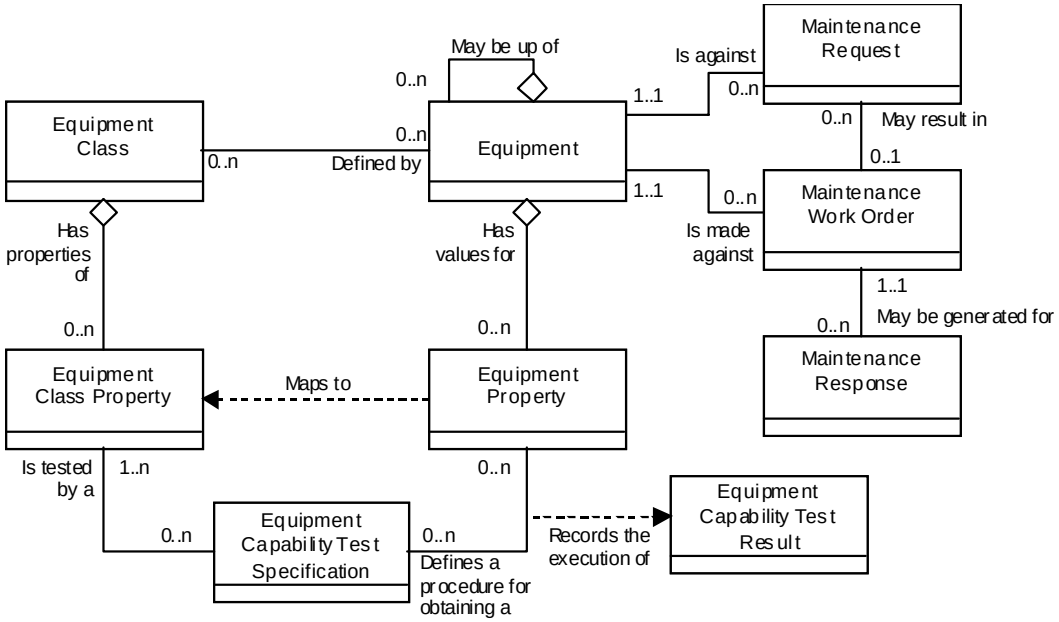


Figure 5 — Equipment model

4.6.1 Equipment

Table 22 defines the attributes for *equipment* objects.

Table 22 — Equipment attributes

Attribute Name	Description	Example
ID	A unique identification of a specific piece of equipment, within the scope of the information exchanged (*production capability, production schedule, production performance*, …) The equipment ID shall be used in other parts of the model when the equipment needs to be identified, such as the *production capability* for a piece of equipment, or a *production response* identifying the equipment used.	Jig 347
Description	Additional information about the equipment.	“This is the east side, north building, widget jig.”

4.6.2 Equipment property

Table 23 defines the attributes for *equipment property* objects.

Table 23 — Equipment property attributes

Attribute Name	Description	Examples
ID	An identification of the specific property.	Equipment Name
		Run Rate
		Template Size
Description	Additional information about the *equipment property.*	“Local name for the widget machine.”
		“Widget making average run rate”
		“Widget jig template size.”
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 *equipment property*.	Big Bertha
		59
		300
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
		Widgets/Hour
		cm

4.6.3 Equipment class

Table 24 defines the attributes for *equipment class* objects.

Table 24 — Equipment class attributes

Attribute Name	Description	Example
ID	A unique identification of a specific *equipment class*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance*, …) The ID shall be used in other parts of the model when the *equipment class* needs to be identified, such as the *production capability* for this equipment class, or a *production response* identifying the equipment class used.	WJ6672892
Description	Additional information about the *equipment class*.	“Jigs used to assemble widgets.”

4.6.4 Equipment class property

Table 25 defines the attributes for *equipment class property* objects.

Table 25 — Equipment class property attributes

Attribute Name	Description	Examples
ID	An identification of the specific property.	Run Rate
		Template Size
Description	Additional information about the *equipment class property*.	“Range of run rate for the widget machines.”
		“Range of template sizes for widget machines.”
Value	The value, set of values, or range of the property.	{1..100}
		{10,20,30,40,100,200,300}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Widgets/Hour
		cm

4.6.5 Equipment capability test specification

Table 26 defines the attributes for *equipment capability test specification* objects.

Table 26 — Equipment capability test specification attributes

Attribute Name	Description	Example
Name	An identification of a test for certifying one or more values for one or more *equipment properties*. For example, this may be the name of a document that describes or defines the capability test.	WAJTT-101
Description	Additional information about the *equipment capability test specification*.	“Widget assembly jig throughput test – returns the run rate for a specific machine”
Version	An identification of the version of the capability test specification. In cases where there are multiple versions of an equipment capability test specification, then the version attribute shall contain the additional identification information to differentiate each version.	1.0

4.6.6 Equipment capability test result

Table 27 defines the attributes for *equipment capability test result* objects.

Table 27 — Equipment capability test result attributes

Attribute Name	Description	Example
ID	A unique instance identification that records the results from the execution of a test identified in a *capability test specification* for a specific piece of *equipment*. (For example, this may just be a number assigned by the testing authority.)	FQ101/01-10-2000
Description	Additional information about the *equipment capability test result*.	“Results from run rate test for JIG 237 for October 1999.”
Date	The date and time of the capability test.	1999-10-25 13:30
Result	The result of the capability test.	48
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	Widgets/Hour
Expiration	The date of the expiration of the capability.	2000-10-25 13:30

4.6.7 Maintenance request

Table 28 defines the attributes for *maintenance request* objects.

Table 28 — Maintenance request attributes

Attribute Name	Description	Example
ID	A unique identifier of a specific *maintenance request*.	MR-1001029928
Problem	A description of the maintenance issue.	“Limit Switch, XS101, failed ON. PLC X24 input forced to OFF.”
Requested Completion Date	Date and time the request is expected to be completed.	2000-03-30 10:00 EST
Requested Priority	The initially defined priority of the *maintenance request*.	HIGH
Requestor	An identification of the person, system, or equipment making the *maintenance request*.	ID# 236663
Status	The status of *maintenance request*. For example: Submitted, Denied, Closed, In Work, In Review.	Submitted
Reviewer	An identification of the person, system, or equipment reviewing the *maintenance request*.	ID# 236664
Submission Date	Date and time of maintenance request submission.	2000-03-28 10:33 EST
Published Date	The date and time on which the *maintenance request* was published or generated.	2000-03-30 18:55 EST

4.6.8 Maintenance work order

Table 29 defines the attributes for *maintenance work order* objects.

Table 29 — Maintenance work order attributes

Attribute Name	Description	Example
ID	A unique identifier of a specific *maintenance work order.*	WO-1001029928
Planned Start	The planned start date and time for the *maintenance work order.*	2000-03-29 16:00 EST
Planned Finish	The planned finish date and time for the *maintenance work order.*	2000-03-29 18:30 EST
Responsible Person	Person or function responsible for work order, or assigned to work.	Second Shift Maintenance Crew
Resources	List of resources needed to perform the work.	{Duct Tape, Safety Glasses, Breathing Air}
Status	Current status of the work order, for example “in work”, “not started”, “assigned”.	Assigned

4.6.9 Maintenance response

Table 30 defines the attributes for *maintenance response* objects.

Table 30 — Maintenance response attributes

Attribute Name	Description	Examples
ID	A unique identifier of a response to a specific *maintenance work order.*	MR-1001029928-01
		MR-1001029928-02
		MR-1001029928-03
Cause	The diagnosis of the fault or problem, or reason for *maintenance work order*.	Wet Floor
		Bad Duct Tape
		Preventive maintenance
Correction	The action taken to perform the work.	“Wet Floor sign placed on wet area”
		“Duct Tape replaced”
		“Filters replaced”
Actual Start	The actual start date and time for the work order.	2000-03-29 16:00 EST
		2000-03-29 16:00 EST
		2000-03-29 16:00 EST
Actual Finish	The actual finish date and time for the work order. Empty if this is a status update response or work is incomplete.	2000-03-31 18:30 EST
		2000-03-31 18:30 EST
Status	Status of the work order as of the current update period.	“In process”
		”Suspended”
		“Completed”
Status Time	Time and date stamp for the *maintenance response*	2000-03-30 18:30 EST
		2000-03-30 18:30 EST
		2000-03-30 18:30 EST
Published Date	The date and time on which the *maintenance response* was published or generated.	2000-03-30 18:55 EST
		2000-03-30 18:55 EST
		2000-03-30 18:55 EST
Consumable	List of resources consumed as part of the work	“Wet floor” sign
		“2 rolls duct tape”
		“18x32 air filters”
Responsible Person	Person or function responsible for response	Second Shift Maintenance Crew
		999-12-3456
		Bill

4.7 Material model

Figure 6 is a copy of Figure 19 in Part 1. An additional association is shown between a QA Test Specification and a Material Class Property.

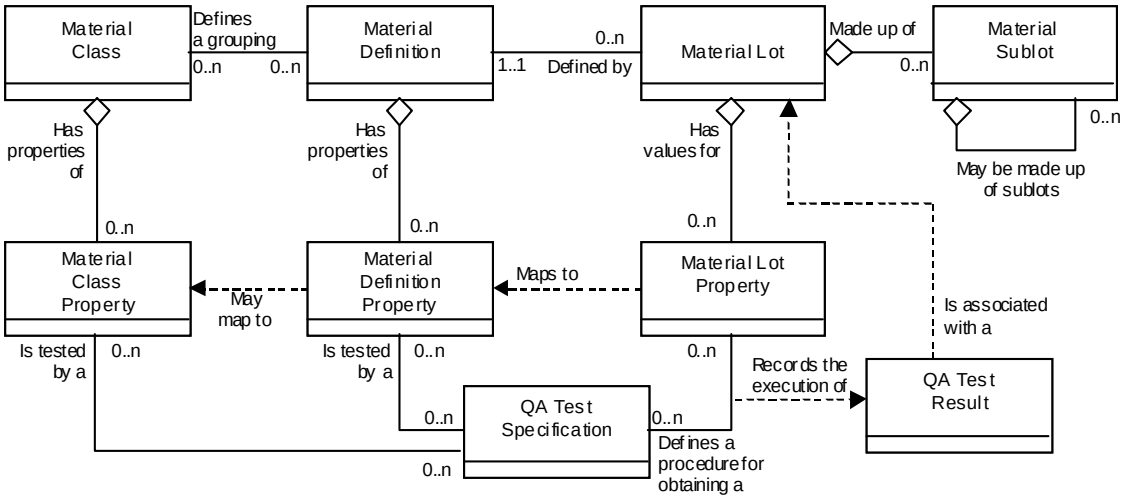


Figure 6 — Material model

4.7.1 Material class

Table 31 defines the attributes for *material class* objects.

Table 31 — Material class attributes

Attribute Name	Description	Example
ID	A unique identification of a specific *material class*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance*, …) The ID shall be used in other parts of the model when the *material class* needs to be identified, such as the *production capability* for this *material class*, or a *production response* identifying the *material class* used.	Polymer sheet stock 1001A
Description	Additional information about the *material class*.	“Solid polymer resin”

4.7.2 Material class property

Table 32 defines the attributes for *material class property* objects.

Table 32 — Material class property attributes

Attribute Name	Description	Example
ID	An identification of a specific *material class property*.	Polyethylene sheets
Description	Additional information about the *material class property*.	“Sheet Thickness”
Value	The value, set of values, or range of the property.	{5, 10, 25}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm

4.7.3 Material definition

Table 33 defines the attributes for *material definition* objects.

Table 33 — Material definition attributes

Attribute Name	Description	Example
ID	A unique identification of a specific *material definition*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance*, …) The ID shall be used in other parts of the model when the *material definition* needs to be identified, such as the *production capability* for this *material definition*, or a *production response* identifying the *material definition* used.	Sheet stock 1443a
Description	Additional information about the *material definition*.	General purpose sheet stock

4.7.4 Material definition property

Table 34 defines the attributes for *material definition property* objects.

Table 34 — Material definition property attributes

Attribute Name	Description	Example
ID	An identification of the specific material definition property.	1443a5mm
Description	Additional information about the *material definition property*.	5 millimeter sheet
Value	The value, set of values, or range of the property.	5
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm

4.7.5 Material lot

Table 35 defines the attributes for *material lot* objects.

Table 35 — Material lot attributes

Attribute Name	Description	Example
ID	A unique identification of a specific *material lot*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance*, …) The ID shall be used in other parts of the model when the *material lot* needs to be identified, such as the *production capability* for this *material lot*, or a *production response* identifying the *material lot* used.	L66738-99
Description	Additional information about the material lot.	PlastiFab 10/31 shipment
Status	Status of the *material lot*. For example, released, approved, blocked, in process, in quality check.	In process

4.7.6 Material lot property

Table 36 defines the attributes for *material lot* objects.

Table 36 — Material lot property attributes

Attribute Name	Description	Examples
ID	An identification of the specific *material lot property*.	Average sheet thickness
		Density
Description	Additional information about the *material lot property*.	Measured thickness
		Measured Density
Value	The value, set of values, or range of the property.	5.002
		34.5
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm
		kg/liter

4.7.7 Material sublot

Table 37 defines the attributes for *material sublot* objects.

Table 37 — Material sublot attributes

Attribute Name	Description	Examples
ID	A unique identification of a specific *material sublot,* within the scope of the information exchanged (*production capability*, *production schedule*, *production performance* …) The ID shall be used in other parts of the model when the *material sublot* needs to be identified, such as the *production capability* for this *material sublot*, or a *production response* identifying the *material sublot* used.	1999-10-27-a67-B6653
Description	Additional information about the *material sublot*.	Pallet 2 of 6
Status	Status of the current *material sublot*. For example, released, approved, blocked, in process, in quality check.	Released
Storage Location	An identification of the storage location of the *material sublot*.	“Warehouse 1 Rack 12 Slot 4”
Quantity	The quantity of the *material sublot.*	40
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	sheets

4.7.8 QA test specification

Table 38 defines the attributes for *QA test specification* objects.

Table 38 — QA test specification attributes

Attribute Name	Description	Example
Name	An identification of a test for certifying one or more values for one or more *equipment properties*. For example, this may be the name of a document that describes or defines the capability test.	STMT-101
Description	Additional information about the *QA Test Specification*.	“Sheet thickness measurement test – returns the average sheet thickness based on a sample plan and technique for a specific lot”
Version	An identification of the version of the *QA test specification*. In cases where there are multiple versions of a QA test specification, then the version attribute shall contain the additional identification information to differentiate each version.	1.0

4.7.9 QA test result

Table 39 defines the attributes for *QA test result* objects.

Table 39 — QA test result attributes

Attribute Name	Description	Example
ID	A unique instance identification that records the results from the execution of a test identified in a *QA test specification* for a lot or sublot. (For example, this may just be a number assigned by the testing authority.)	THK101/01-10-2000
Description	Additional information about the *QA Test Result*.	“Results from thickness test for PlastiFab lot on 1999-10-25”
Date	The date of the QA test.	1999-10-25 11:30
Result	The value or list of values returned from the performance of the QA test. For example: Pass, Fail, 95, Red, Green.	Pass
Result Unit of Measure	The unit of measure of the associated test result, if applicable.	[not applicable]
Expiration	The date of the expiration of the test results.	2000-10-25 13:30

4.8 Process segment model

Figure 7 is a copy of Figure 20 in Part 1, with a clarification of the relationship to the personnel, equipment, and material models, and with an additional object to contain the *process segment dependency*.

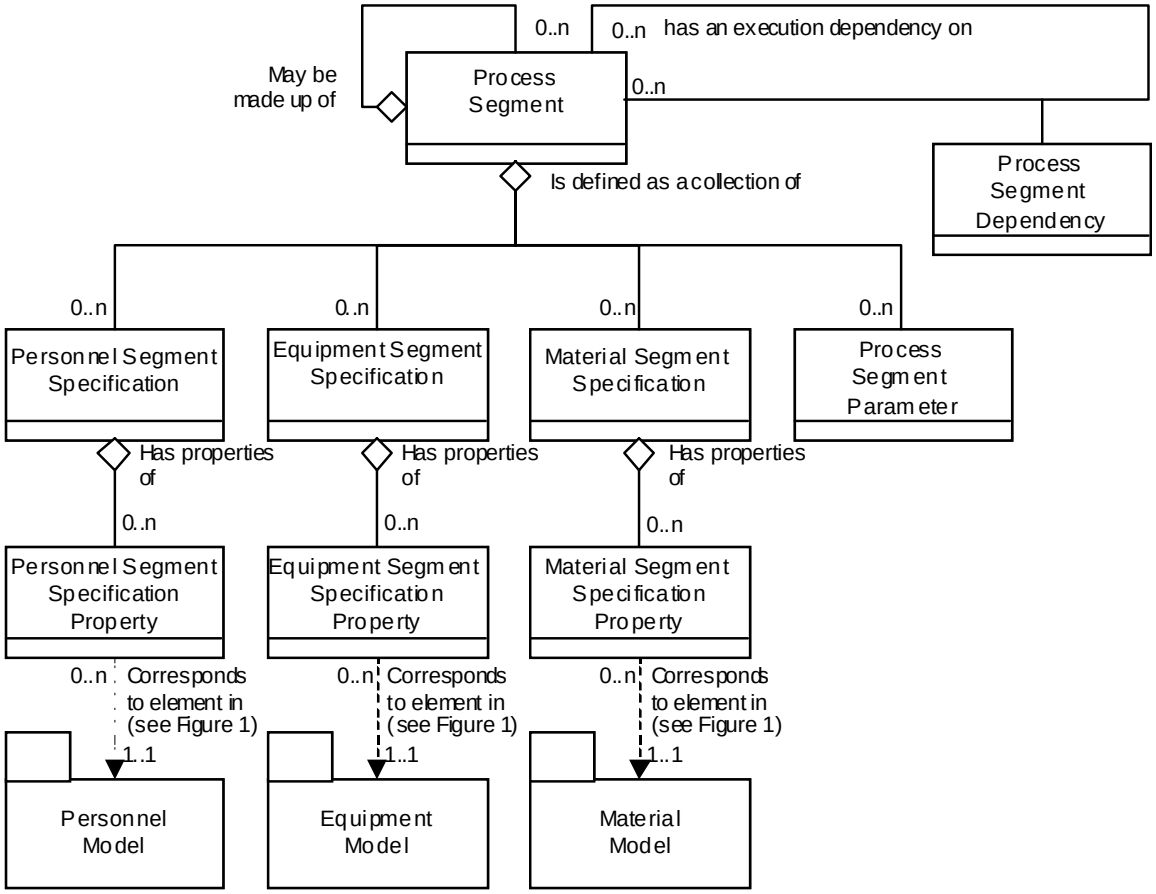


Figure 2 — Process segment model

4.8.1 Process segment

Table 40 defines the attributes for *process segment* objects.

Table 40 — Process segment attributes

Attribute Name	Description	Examples
ID	A unique identification of a *process segment*, within the scope of the information exchanged (*production capability*, *production schedule*, *production performance* …) The ID shall be used in other parts of the model when the *process segment* needs to be identified, such as the *production capability* for this segment, or a *production response* identifying the segment.	Widget Frame Milling
		Widget Top Assembly
		Widget Final Assembly
Description	Additional information about the *process segment*.	“Frame milling operation, separately costed operation”
		“Top Assembly operation, separately costed operation”
		“Final Assembly operation, separately costed operation”
Location	An identification of the associated element of the equipment hierarchy model. Optionally defines the scope of the process segment definition, such as the site or area it is defined for.	South Shore Production Line
		East Wing Manufacturing Line #2
		East Wing Manufacturing Line #3
Element Type	A definition of the type of the associated element of the equipment hierarchy model.	Site
		Production line
		Production Line
Published Date	The date and time on which the *process segment* was published or generated.	1999-11-12 13:55
		1999-11-12 13:55
Duration	Duration of process segment, if known.	25
		2
Duration Unit of Measure	The units of measure of the duration, if defined.	Minutes
		Hours

4.8.2 Personnel segment specification

Table 41 defines the attributes for *personnel segment specification* objects.

Table 41 — Personnel segment specification attributes

Attribute Name	Description	Example
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* of the specification for a specific *process segment*.	Milling Machine Operator
Person	Identifies the associated *person* or set of *persons* of the specification for a specific *process segment*.	{999-55-1212, 999-55-1234, 999-55-4567}
Description	Contains additional information and descriptions of the *personnel segment specification* definition.	“Defines the time for journeyman milling machine operators for each widget frame milling process segment.”
Quantity	Specifies the personnel resource required for the parent *process segment*, if applicable.	1.3
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece

4.8.3 Personnel segment specification property

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

Table 42 — Personnel segment specification property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *person property* or *personnel class property* for a specific *process segment*.	Height
Description	Contains additional information and descriptions of the *personnel segment specification property* definition.	“Defines the required minimum height of a milling machine operator.”
Value	The value, set of values, or range of the property.	150
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	cm
Quantity	Specifies the personnel resource required for the parent *process segment*, if applicable.	1.3
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece

4.8.4 Equipment segment specification

Table 43 defines the attributes for *equipment segment specification* objects.

Table 43 — Equipment segment specification attributes

Attribute Name	Description	Example
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* of the capability for a specific *process segment*.	Milling Machine
Equipment	Identifies the associated *equipment* or set of *equipment* of the capability for a specific *process segment*.	{Mill 15, Mill 16, Mill 19}
Description	Contains additional information and descriptions of the *equipment segment specification* definition.	“Equipment needed for widget milling process segment”
Quantity	Specifies the amount of resources required for the parent *process segment*, if applicable.	1.3
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Machine Hours / piece

4.8.5 Equipment segment specification property

Table 44 defines the attributes for *equipment segment specification property* objects.

Table 44 — Equipment segment specification property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *equipment property* or *equipment class property* for a specific *process segment*.	Milling Direction
Description	Contains additional information and descriptions of the *equipment segment specification property* definition.	“Only vertical milling machines are suitable for widget milling.”
Value	The value, set of values, or range of the property. For example: Vertical, Horizontal.	Vertical
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of resources required for the parent *process segment*, if applicable.	1.0
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Machine hours / piece

4.8.6 Material segment specification

Table 45 defines the attributes for *material segment specification* objects.

Table 45 — Material segment specification attributes

Attribute Name	Description	Examples
Material Class	Identifies the associated *material class* or set of *material classes* of the capability for a specific *process segment*.*	Polymer sheet stock 1001A
		Rivet
Material Definition	Identifies the associated material definition or set of *material definitions* of the capability for a specific *process segment*. *	Sheet stock 1443a
		Rivet-10002
Description	Contains additional information and descriptions of the *material segment specification* definition.	“Defines the polymer required for a widget milling process segment.”
		“Defines the rivet material required for a widget milling process segment.”
Material Use	Defines the material use: Material Consumed, Material Produced, or Consumable	Material Consumed
		Material Consumed
Quantity	Specifies the amount of resources required for the parent *process segment*, if applicable.	0.35
		6
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	Sheets / piece
		Number / piece

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

4.8.7 Material segment specification property

Table 46 defines the attributes for *material segment specification property* objects.

Table 46 — Material segment specification property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *material property* or *equipment class property* for a specific *process segment*.	Average Surface Roughness
Description	Contains additional information and descriptions of the *material segment specification property* definition.	“Defines the minimum polyethylene roughness quality.”
Value	The value, set of values, or range of the property.	66.748
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Angstroms
Quantity	Specifies the amount of resources required for the parent *process segment*, if applicable.	0.10
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	Sheets / piece

4.8.8 Process segment parameter

Table 47 defines the attributes for *process segment parameter* objects.

Table 47 — Process segment parameter attributes

Attribute Name	Description	Example
Name	Name of the *process segment parameter* for a specific *process segment.*	Milling Time
Description	Contains additional information of the *process segment parameter.*	“Range of acceptable milling times.”
Value	The value, set of values, or range of acceptable values	{5..10}
Unit of Measure	Unit of measure of the values, if applicable.	Minutes

4.8.9 Process segment dependency

Table 48 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. For example, it may define that an inspection segment must follow an assembly segment.

Table 48 — Process segment dependency attributes

Attribute Name	Description	Example
Description	Contains additional information and descriptions of the *process segment dependency* definition for a specific *process segment*.	"Defines the ordering of assembly processes for the Widget Assembly process segment"
Dependency Type	Defines the execution dependency constraints of one segment by another segment. Examples of these constraints, using A and B to identify the segments, or specific resources within the segments, and T to identify the timing factor, 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 (*Timing Factor*) after A start Start B no earlier than T (*Timing Factor*) after A start Start B no later than T (*Timing Factor*) after A end Start B no earlier than T (*Timing Factor*) after A end	Start *Cleanout* no earlier than T (*Timing Factor*) after *Production* end
Timing Factor	Timing factor used by dependency	25
Time Unit of Measure	The units of measure of the timing factor, if defined.	Minutes

4.9 Product definition information model

Figure 8 below is a copy of Figure 21 in Part 1, with a clarification of the relationship to *process segments*, the personnel, equipment, and material models, and an object to contain the *product segment dependencies*. The *Product Production Rule* also is depicted as an object, instead of a package, as in Part 1.

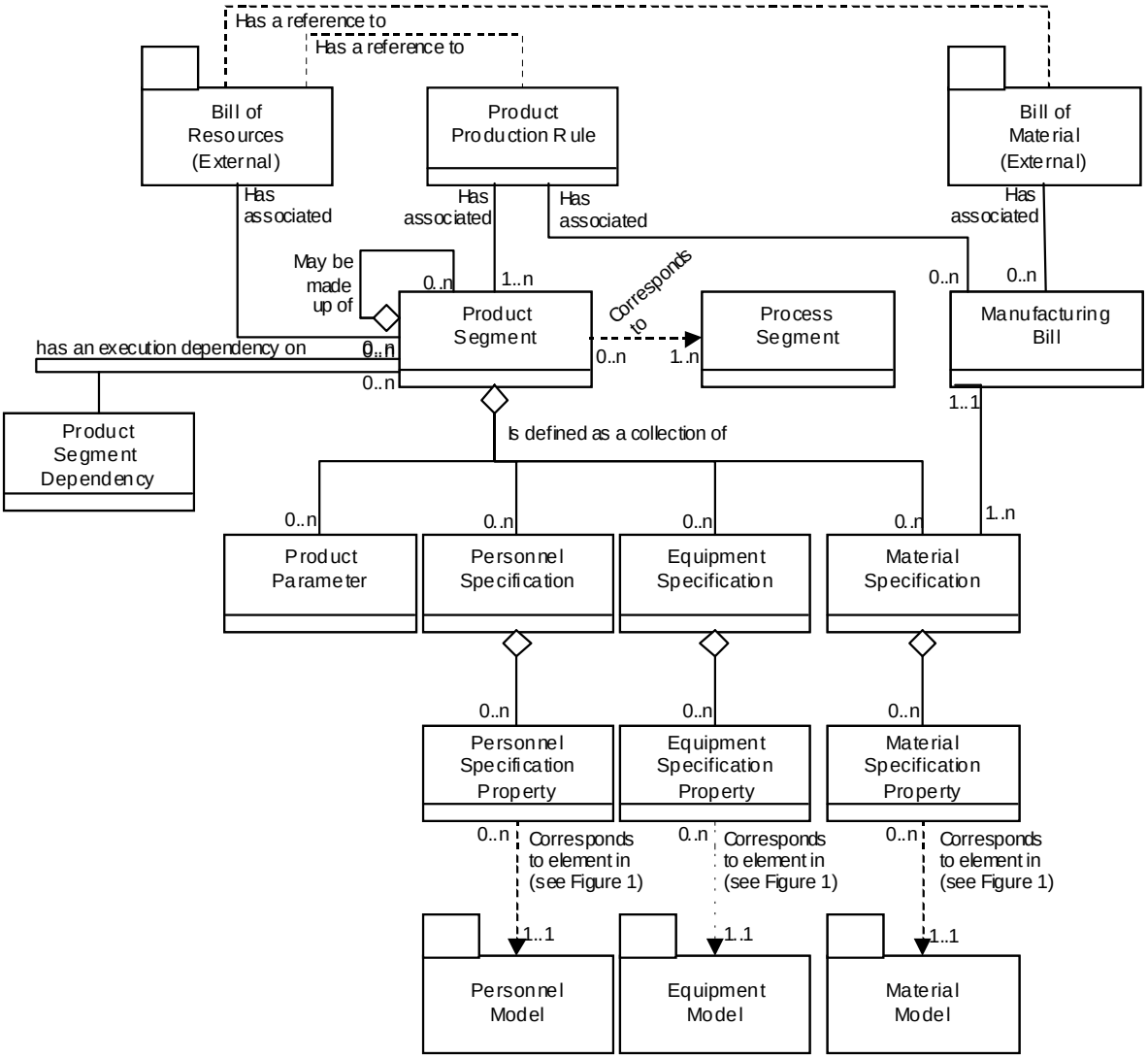


Figure 8 — Product definition model

4.9.1 Product production rule

Table 49 defines the attributes for *product production rule* objects.

Table 49 — Product production rule attributes

Attribute Name	Description	Example
ID	Uniquely identifies the product. The ID shall be used in other parts of the model when the *product production rule* needs to be identified.	Export Quality Widget
Version	An identification of the version of the *product production rule*. In cases where there are multiple versions of a *product production rule*, then the version attribute shall contain the additional identification information to differentiate each version.	1.0
Description	Contains additional information and descriptions of the *product production rule.*	“Information defining resources required for production of a single ‘Export Quality Widget’”.
Published Date	The date and time on which the *production capability* was published or generated.	1999-11-12 13:55
Duration Unit of Measure	The units of measure of the duration, if defined.	Minutes

4.9.2 Manufacturing bill

Table 50 defines the attributes for *manufacturing bill* objects.

Table 50 — Manufacturing bill attributes

Attribute Name	Description	Example
ID	A unique identification of a *manufacturing bill*.	10000827
Description	Contains additional information of the *manufacturing bill.*	“All materials required in the manufacturing process for a single widget.”
Material Class	Identifies the associated *material class* or set of *material classes* required for production. Only the material class or the material property is usually defined.	{Polymer sheet stock 1001A, Rivets}
Material Definition	Identifies the associated *material definition* or set of *material definitions* required for production.	{Sheet stock 1443a , Rivet-10002}
Quantity	Specifies the amount of resources required for production.	{1.0, 26}
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	{Sheets / piece, Number / piece}

4.9.3 Product segment

Table 51 defines the attributes for *product segment* objects.

Table 51 — Product segment attributes

Attribute Name	Description	Example
ID	A unique identification of a specific *product segment* within the scope of the information exchanged. The ID shall be used in other parts of the model when the *product segment* needs to be identified.	Final Polished Widget
Description	Contains additional information of the *product segment*	“A brightly polished widget.”
Duration	Duration of *product segment*, if known.	25
Process Segment	Identifies the associated process segments. There may be multiple alternate process segments that could be used for the product segment.	Widget Polishing

4.9.4 Product parameter

Table 52 defines the attributes for *product parameter* objects.

Table 52 — Product parameter attributes

Attribute Name	Description	Example
Name	Name of the *product parameter* for a specific *product segment.*	Widget roughness
Description	Contains additional information of the *product parameter.*	“Range of acceptable surface roughness to be manufactured.”
Value	The value, set of values, or range of acceptable values.	{80..2500}
Value Unit of Measure	Unit of measure of the values, if applicable.	Angstroms

4.9.5 Personnel specification

Table 53 defines the attributes for *personnel specification* objects.

Table 53 — Personnel specification attributes

Attribute Name	Description	Example
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* of the specification for a specific *product segment*.	Widget Polisher
Person	Identifies the associated *person* or set of *persons* of the specification for a specific *product segment*.	999-12-3456
Description	Contains additional information of the *personnel specification*.	“Polisher skill required for export quality polished widget”
Quantity	Specifies the amount of personnel resources required for the parent *product segment*, if applicable.	0.25
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece

4.9.6 Personnel specification property

Table 54 defines the attributes for *personnel specification property* objects.

Table 54 — Personnel specification property attributes

Attribute Name	Description	Examples
Property Name	An identification of a property of the associated *person property* or *personnel class property* for a specific *product segment*.	Polishing Certification Level
Description	Contains additional information and descriptions of the *personnel specification property* definition.	“Level of polishing skill certification required for the widget polisher”
Value	The value, set of values, or range of the property. For example: Apprentice, Journeyman, Master.	Master
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of personnel resources required for the parent *product segment*, if applicable.	0.10
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Hours / piece

4.9.7 Equipment specification

Table 55 defines *equipment specification* object.

Table 55 — Equipment specification attributes

Attribute Name	Description	Example
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* of the specification for a specific *product segment*.	Widget Polishing Machine
Equipment	Identifies the associated *equipment* or set of *equipment* of the specification for a specific *product segment*.	WPM-10
Description	Contains additional information and descriptions of the *equipment specification.*	“Equipment required to polish Export Quality Widgets.”
Quantity	Specifies the amount of equipment resources required for the parent *product segment*, if applicable.	1.25
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Minutes / piece

4.9.8 Equipment specification property

Table 56 defines the attributes for *equipment specification property* objects.

Table 56 — Equipment specification property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *equipment property* or *equipment class property* for a specific *product segment*.	Polisher Type
Description	Contains additional information and descriptions of the *equipment specification property* definition.	“Wet polisher required for Export Quality Widget polishing.”
Value	The value, set of values, or range of the property. For example: Wet, Dry.	Wet
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of equipment resources required for the parent *product segment*, if applicable.	0.10
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Minutes / piece

4.9.9 Material specification

Table 57 defines *material specification* objects.

Table 57 — Material specification attributes

Attribute Name	Description	Example
Material Class	Identifies the associated *material class* or set of *material classes* of the specification for a specific *product segment*.*	Abrasives
Material Definition	Identifies the associated *material definition* or set of *material definition* of the specification for a specific *product segment*.*	Rouge
Description	Contains additional information and descriptions of the *material specification*.	“Polishing material for Export Quality Widget polishing.”
Material Use	Defines the material use: Material Consumed, Material Produced, or Consumable.	Material Consumed
Quantity	Specifies the amount of material resources required for the parent *product segment*, if applicable.	10
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	gm / piece

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

4.9.10 Material specification property

Table 58 defines the attributes for *material specification property* objects.

Table 58 — Material specification property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *material property* for a specific *product segment*.	Grit Size
Description	Contains additional information and descriptions of the *material specification property.*	“Measure of required grit size for Export Quality Widget polishing.”
Value	The value, set of values, or range for the associated property.	{1300..1500}
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Grit Number
Quantity	Specifies the amount of material resources required for the parent *product segment*, if applicable.	5
Quantity Unit of Measure	The unit of measure of the associated property value, if applicable.	gm / piece

4.9.11 Product segment dependency

Table 59 defines the attributes for *product segment dependency* objects. The *product segment dependencies* can be used to describe dependencies that are product specific. For example, a wheel assembly and a frame assembly that can run in parallel.

Table 59 — Product segment dependency attributes

Attribute Name	Description	Example
Description	Contains additional information and descriptions of the *product segment dependency* definition for a specific *product segment*.	“Defines the ordering of widget washing during the Widget Assembly product segment”
Dependency Type	Defines the execution dependency constraints of one segment by another segment. Examples of these constraints, using A and B to identify the segments, or specific resources within the segments, and T to identify the timing factor, 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 (*Timing Factor*) after A start Start B no earlier than T (*Timing Factor*) after A start Start B no later than T (*Timing Factor*) after A end Start B no earlier than T (*Timing Factor*) after A end	Start *Acid Addition* no later than *T* (*Timing Factor*) after *Reaction Complete* end
Timing Factor	Timing factor used by dependency.	25
Time Unit of Measure	The units of measure of the timing factor, if defined.	Minutes

4.10 Production schedule model

Figure 9 is a copy of Figure 22 in Part 1, with a clarification of the relationship to *product segments*, *process segments*, the personnel, equipment, and material models.

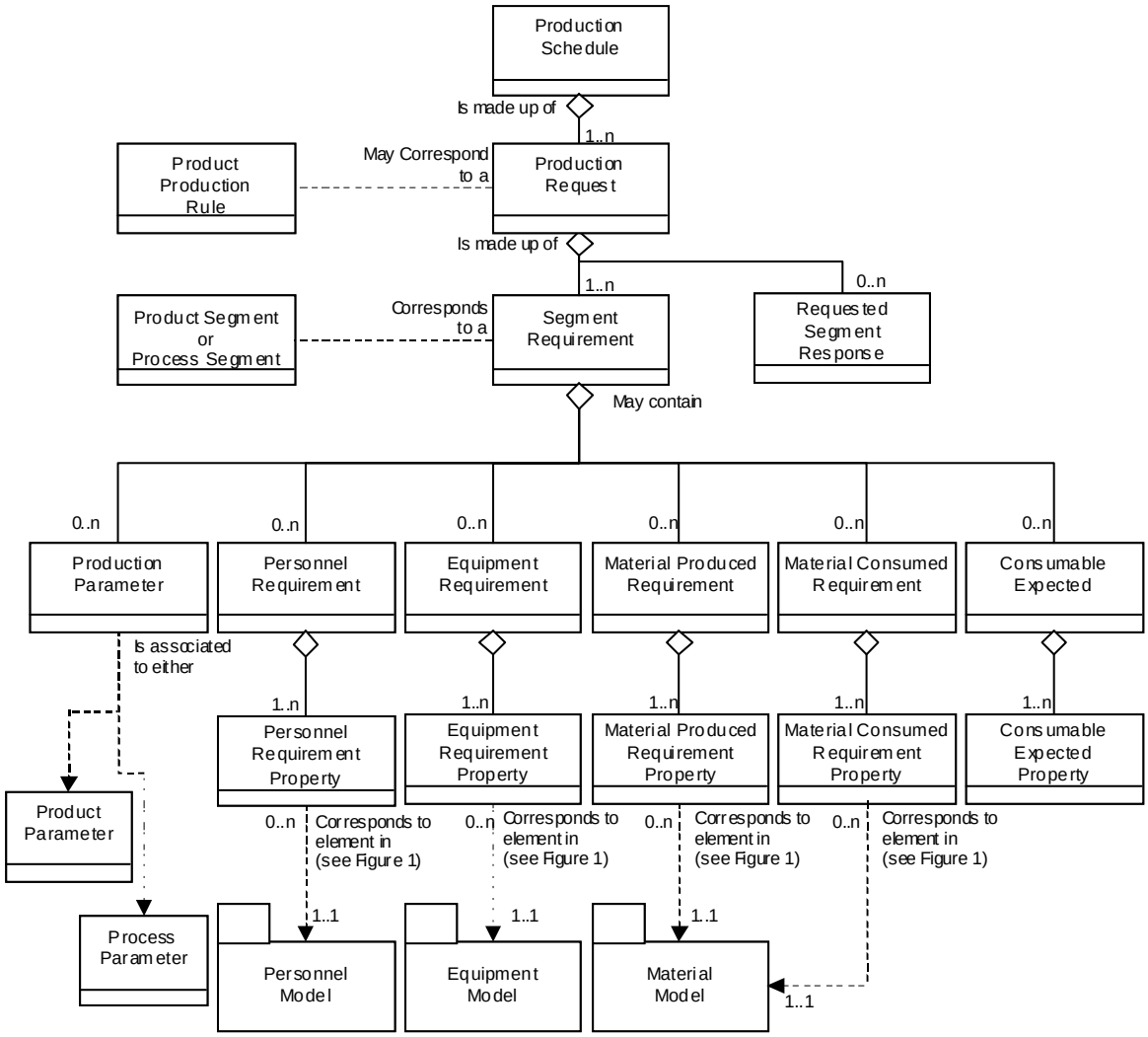


Figure 9 — Production schedule model

4.10.1 Production schedule

Table 60 defines the attributes for *production schedule* objects.

Table 60 — Production schedule attributes

Attribute Name	Description	Example
ID	A unique identification of the *production schedule* and could include version and revision identification. The ID shall be used in other parts of the model when the *production schedule* needs to be identified.	1999-10-27-A15
Description	Contains additional information and descriptions of the *production schedule.*	“Widget manufacturing schedule.”
Start Time	The starting time for the associated *production schedule*, if applicable.	10-28-1999
End Time	The ending time for the associated *production schedule*, if applicable.	10-30-1999
Published Date	The date and time on which the *production schedule* was published or generated.	12-30-1951 18:30 UTC
Location	An identification of the associated element of the equipment hierarchy model.	East Wing Manufacturing Line #2
Element Type	A definition of the type of the associated element of the equipment hierarchy model. For example: enterprise, site, area.	Production line

4.10.2 Production request

Table 61 defines the attributes for *production request* objects.

Table 61 — Production request attributes

Attribute Name	Description	Example
ID	A unique identification of the *production request.* The ID shall be used in other parts of the model when the *production request* needs to be identified.	1001091
Description	Contains additional information and descriptions of the *production request.*	“Production Request for export quality widgets for October 29, 1999.”
Product Production Rule	Identifies the associated *product production rule* to be used, if applicable.	Export Quality Widget
Start Time	When production is to be started, if applicable.	1999-10-27 8:00 UTC
End Time	When production is to be completed, if applicable.	1999-10-27 17:00 UTC
Priority	The priority of the request, if applicable.	Highest

4.10.3 Segment requirement

Table 62 defines the attributes for *segment requirement* objects.

Table 62 — Segment requirement attributes

Attribute Name	Description	Examples
ID	A unique identification of the *segment requirement* within the scope of a *production request*.	A54
		A6646
Segment	An identification of the *process segment* or *product segment* associated with the *segment requirement*, if applicable.	Master Segment
		Polishing Segment
Description	Contains additional information and descriptions of the *segment requirement.*	“Master segment, containing customer name and final produced material requirements.”
		“Polishing segment, containing specifications for personnel, materials and equipment.”
Earliest Start Time	The expected earliest start time of this *segment requirement*, if applicable.	1999-10-27 8:33 UTC
		1999-10-27 14:13 UTC
Latest End Time	The expected latest ending time of this *segment requirement*, if applicable.	1999-10-27 16:55 UTC
		1999-10-27 16:55 UTC
Duration	The expected duration of this segment requirement, if applicable. Note, this should match the associated *product segment* or *process segment* duration.	1
		15
Duration Unit of Measure	The unit of measure of the duration, if applicable.	Hour
		Minutes

There are multiple segments defined in the example. There is one master segment of production that applies to the entire production request. The master segment is made up of multiple nested segments for individually specified and reported segments of production.

For example, information that applies across all segments of the production request, such as a customer name, may be represented as a production parameter in the master segment.

Information that applies to specific segments of production, such as widget polishing equipment utilization, may be specified as part of the polishing segment.

4.10.4 Production parameter

Table 63 defines the attributes for *production parameter* objects.

Table 63 — Production parameter attributes

Attribute Name	Description	Examples
Name	The *production parameter* name.	Customer Name
		Widget Clock Speed
		Polishing Finish
Description	Contains additional information and descriptions of the *production parameter.*	“Master Segment - Customer Name”
		“Minimum Widget clock speed.”
		“Polishing Segment - Polishing Finish”
Value	The value, set of values, or range of the value to be used for this parameter.	Bridgett’s Widgetts Store
		200
		High Gloss
Value Unit of Measure	The engineering units in which the value is defined, if applicable.	[not applicable]
		MHz
		[not applicable]

4.10.5 Personnel requirement

Table 64 defines the attributes for *personnel requirement* objects.

Table 64 — Personnel requirement attributes

Attribute Name	Description	Example
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* of the requirement for a specific *segment requirement*.	Widget Polisher
Person	Identifies the associated *person* or set of *persons* of the requirement for a specific *segment requirement*. Typically either *personnel class* or *person* is specified, but not both.	Gidget
Description	Contains additional information and descriptions of the *personnel requirement.*	“Defines the specific polishing operator assigned to this production request.”
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable. Applies to each member of the *person* and *personnel class* sets.	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Full Time Equivalents

4.10.6 Personnel requirement property

Table 65 defines the attributes for *personnel requirement property* objects.

Table 65 — Personnel requirement property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *person property* or *personnel class property* for a specific *segment requirement*.	Polishing Certification Level
Description	Contains additional information and descriptions of the *personnel requirement property* definition.	“Level of polishing skill certification required for the widget polisher”
Value	The value, set of values, or range of the property. For example: Apprentice, Journeyman, Master.	Journeyman
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of personnel resources required for the parent segment, if applicable.	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Hour

4.10.7 Equipment requirement

Table 66 defines the attributes for *equipment requirement* objects.

Table 66 — Equipment requirement attributes

Attribute Name	Description	Example
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* of the requirement for a specific *segment requirement*.	Widget Polishing Machine
Equipment	Identifies the associated *equipment* set of *equipment* of the requirement for a specific *segment requirement*. Typically either *equipment class* or *equipment* is specified, but not both.	WPM-19
Description	Contains additional information and descriptions of the *equipment requirement.*	“Specifies the expected machine to be used for this production request.”
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable. Applies to each member of the *equipment* and *equipment class* sets.	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Units

4.10.8 Equipment requirement property

Table 67 defines the attributes for *equipment requirement property* objects.

Table 67 — Equipment requirement property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *equipment property* or *equipment class property* for a specific *segment requirement*.	Polisher Type
Description	Contains additional information and descriptions of the *equipment requirement property* definition.	“Polisher required for this production request.”
Value	The value, set of values, or range of the associated property. For example: Wet, Dry.	Dry
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of equipment resources required for the parent segment, if applicable.	1
Quantity Unit of Measure	The unit of measure of the associated quantity, if applicable.	Units

4.10.9 Material produced requirement

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

Table 68 — Material produced requirement attributes

Attribute Name	Description	Example
Material Class	Identifies the associated *material class* or set of *material classes* of the requirement for a specific *segment requirement*.*	Widgets
Material Definition	Identifies the associated *material definition* or set of *material definitions* of the requirement for a specific *segment requirement.**	Export Quality Widgets
Material Lot	Identifies the associated material lot, or set of *material lots* of the requirement for a specific *segment requirement*.*	BWLOT-2282
Material Sublot	Identifies the associated material sublot, or set of *material sublots* of the requirement for a specific *segment requirement*.*	BWLOT-2282-A
Description	Contains additional information and descriptions of the *material produced requirement* definition.	“Master Segment - Number of Widgets to produce.”
Location	Identifies the proposed location of the produced material, if applicable.	Finished Goods Inventory
Quantity	Specifies the amount of material to be produced, if applicable. Applies to each member of the *material lot*, *materials definition*, or *material class* sets.	1500
Quantity Unit of Measure	Identifies the unit of measure of the quantity if applicable.	Units

* Typically a *material class, material definition, material lot,* or *material sublot* is specified.

4.10.10 Material produced requirement property

Table 69 defines the attributes for *material produced requirement property* objects.

Table 69 — Material produced requirement property attributes

Attribute Name	Description	Example
Property Name	An identification of a property of the associated *material property* or *material class property* for a specific *segment requirement*.	Color
Description	Contains additional information and descriptions of the *material produced requirement property* definition.	“Specifies the color for this specific production request, in the polishing segment.”
Value	The value, set of values, or range of the associated property. For example, Red, Orange, Yellow, Green, Blue, Indigo, Violet.	Red
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of material to be produced, if applicable.	100
Quantity Unit of Measure	Identifies the unit of measure of the quantity if applicable.	Units

4.10.11 Material consumed requirement

Table 70 defines the attributes for *material consumed requirement* objects.

Table 70 — Material consumed requirement attributes

Attribute Name	Description	Examples
Material Class	Identifies the associated *material* class or set of *material classes* of the requirement for a specific *segment requirement*. *	Paint
Material Definition	Identifies the associated *material definition* or set of *material definitions* of the requirement for a specific *segment requirement*.*	Red Paint
Material Lot	Identifies the associated *material lot* or set of *material lots* of the requirement for a specific *segment requirement*. *	GP-RED-42
Material Sublot	Identifies the associated material sublot, or set of *material sublots* of the requirement for a specific *segment requirement*.*	GP-RED-42-A
Description	Contains additional information and descriptions of the *material consumed requirement property* definition.	“Paint to be used to finish the widgets in the polishing segment."
Location	Identifies the location of the material to be consumed, if applicable.	Floor Stock
Quantity	Specifies the amount of material resources required for the parent segment, if applicable. Applies to each member of the *material sublot material lot*, *materials definition*, or *material class* sets.	12
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	355 ml Cans

* Typically a *material class, material definition, material lot,* or *material sublot* is specified.

4.10.12 Material consumed requirement property

Table 71 defines the attributes for *material consumed requirement* objects.

Table 71 — Material consumed requirement property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *material property* or *material class property* for a specific *segment requirement*.	Gloss
Description	Contains additional information and descriptions of the *material consumed requirement property* definition.	“Defines the specific type of red paint to be used for this production request.”
Value	The value, set of values, or range of the property. For example: Flat, Satin, High Gloss.	High Gloss
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of material resources required for the parent segment, if applicable.	6
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	355 ml Cans

4.10.13 Consumable expected

Table 72 defines the attributes for *consumable expected* objects.

Table 72 — Consumable expected attributes

Attribute Name	Description	Example
Material Class	Identifies the associated *material class* or set of *material classes* of the requirement for a specific *segment requirement*.	Tape
Material Definition	Identifies the associated *material definition* or set of *material definitions* of the requirement for a specific *segment requirement*. Typically either *material class or material definition* is specified, but not both.	Masking Tape
Location	Identifies the location of the material to be consumed, if applicable.	Shop Floor
Description	Contains additional information and descriptions of the *consumable*.	“Expected usage of masking tape for polishing segment.”
Quantity	Specifies the amount of material resources required for the parent segment, if applicable. Applies to each member of the *material definition*, or *material class* sets.	3
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Meters

4.10.14 Consumable expected property

Table 73 defines the attributes for *consumable expected property* objects.

Table 73 — Consumable expected property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *material property* or *material class property* for a specific *segment requirement*.	Tape Width
Description	Contains additional information and descriptions of the *consumable expected property* definition.	“Width of the tape expected to be used for this production request.”
Value	The value, set of values, or range of the associated property.	10
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm
Quantity	Specifies the amount of material resources required for the parent segment, if applicable.	1.5
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Meters

4.11 Production performance model

Figure 10 is a copy of Figure 23 in Part 1, with a correspondence to a *product production rule* shown, a clarification of the relationship to the personnel, equipment, and material models.

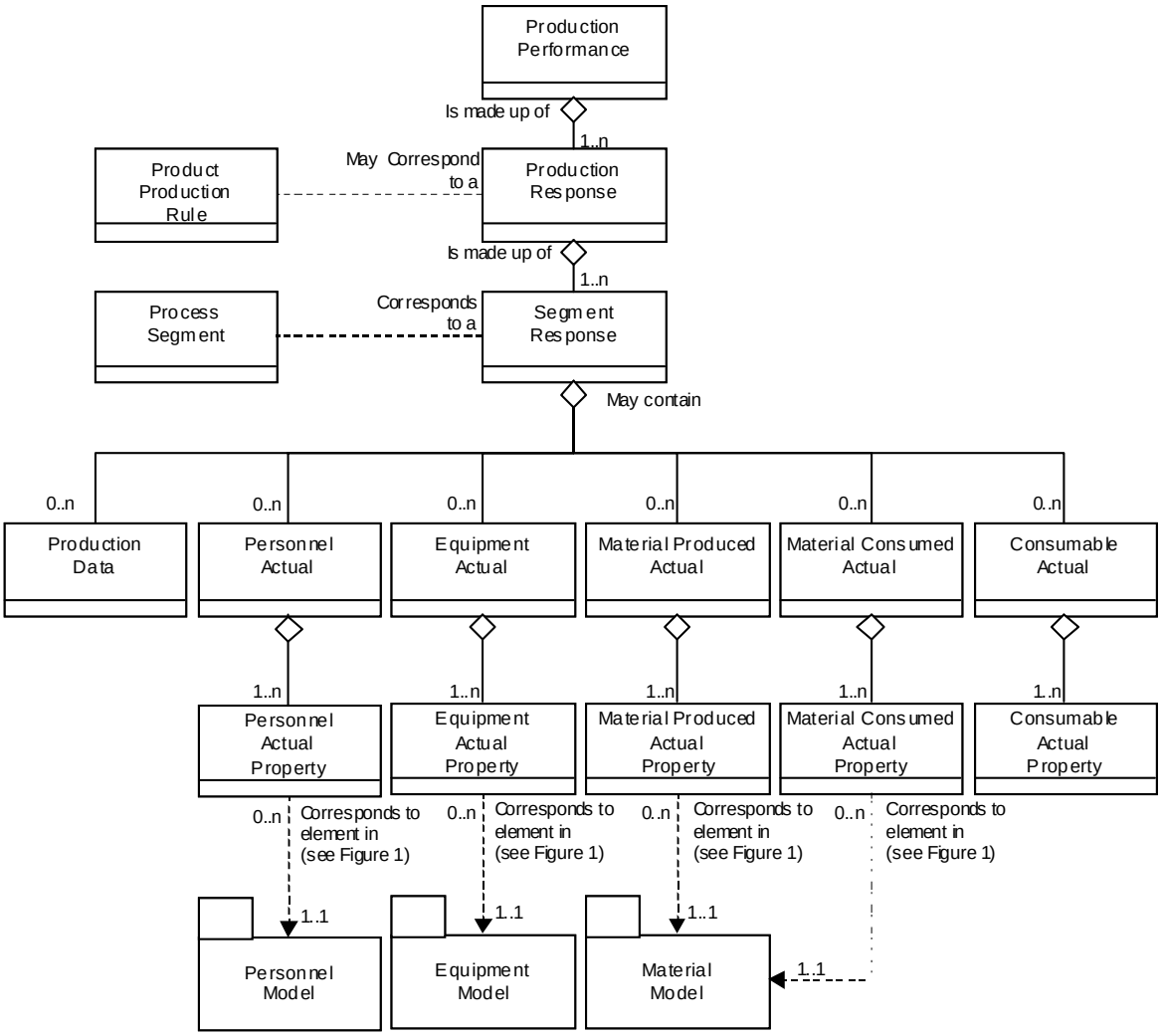


Figure 10 — Production performance model

4.11.1 Production performance

Table 74 defines the attributes for *production performance* objects.

Table 74 — Production performance attributes

Attribute Name	Description	Example
ID	A unique identification of the *production performance* and could include version and revision identification. The ID shall be used in other parts of the model when the *production performance* needs to be identified.	1999-10-27-A15
Description	Contains additional information and descriptions of the *production performance.*	“Production performance report on Oct 27, 1999 production schedule.”
Production Schedule	An identification of the associated *production schedule*, if applicable. *Production performance* may not relate to a *production schedule*, it may be a report on all production for a specific time, or reported on by plant floor events.	1999-10-27-A15
Start Time	The starting time of the associated *production performance*, if applicable.	10-28-1999
End Time	The ending time of the associated *production performance*, if applicable.	10-30-1999
Published Date	The date and time on which the *production performance* was published or generated.	10-27-1999 13:42 EST
Location	An identification of the associated element of the equipment hierarchy model.	East Wing Manufacturing Line #2
Element Type	A definition of the type of associated element of the equipment hierarchy model. For example: enterprise, site, area.	Production Line

4.11.2 Production response

Table 75 defines the attributes for *production response* objects.

Table 75 — Production response attributes

Attribute Name	Description	Example
ID	An identification within the associated *production response*. The ID shall be used in other parts of the model when the *production response* needs to be identified.	1001091
Production Request	An identification of the associated *production request*, if applicable. *Production response* may not relate to a *production request*, it may be a report on all production for a specific time, or reported on by plant floor events.	1001091
Product Production Rule	Identifies the associated *product production rule* that was used, if applicable. This may not match the request, if alternate specifications are allowed.	Export Quality Widget
Start Time	The starting time of this *production response*.	1999-10-27 8:33 UTC
End Time	The ending time of this *production response*.	1999-10-27 16:55 UTC

4.11.3 Segment response

Table 76 defines the attributes for *segment response* objects.

Table 76 — Segment response attributes

Attribute Name	Description	Examples
ID	Uniquely identifies an instance of a *process segment* executed. (Note: the same process segment may be executed multiple times in production.)	A54-1
		A6646
Process Segment	An identification of the *process segment* associated with the *segment response*.	Master Segment
		Polishing Segment
Description	Contains additional information and descriptions of the *segment response.*	“Master segment, containing material produced actuals.”
		“Polishing segment containing personnel, material, and equipment actuals.”
Actual Start Time	The actual start time of this *segment response*.	1999-10-27 8:33 UTC
		1999-10-27 14:13 UTC
Actual End Time	The actual end time of this *segment response*.	1999-10-27 16:55 UTC
		1999-10-27 16:55 UTC

There are multiple segments defined in the example. There is one master segment of production that applies to the entire production response. The master segment is made up of multiple nested segments for individually reported segments of production.

For example, information that applies across all segments of the production response, such as a final material produced, may be represented as a material produced in the master segment.

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

4.11.4 Production data

Table 77 defines the attributes for *production data* objects.

Table 77 — Production data attributes

Attribute Name	Description	Examples
Name	The *production data* name.	Widget Clock Speed
		Explanation
Description	Contains additional information and descriptions of the *production data*.	“Defines the average measured clock speed of the produced widgets."
		“Explanation of deviations from expected.”
Value	The value or set of values of the *production data*.	233
		“Widget polishing machine WPM-19 was out of service, WPM-20 used instead."
Value Unit of Measure	The engineering units in which the value is defined, if applicable.	MHz
		[not applicable]

4.11.5 Personnel actual

Table 78 defines the attributes for *personnel actual* objects.

Table 78 — Personnel actual attributes

Attribute Name	Description	Example
Personnel Class	Identifies the associated *personnel class* or set of *personnel classes* actually used for a specific *segment response*.	Widget Polisher
Person	Identifies the associated *person* or set of *persons* actually used for a specific *segment response*. Typically either *personnel class* or *person* is specified, but not both.	Gidget
Description	Contains additional information and descriptions of the *personnel actual.*	“Defines the specific polishing operator used in production request.”
Quantity	Specifies the amount of personnel resources used in the parent segment, if applicable. Applies to each member of the *person* and *personnel class* sets.	1
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Full Time Equivalents

4.11.6 Personnel actual property

Table 79 defines the attributes for *personnel actual property* objects.

Table 79 — Personnel actual property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *person property* or *personnel class property* for a specific *segment response*.	Polishing Certification Level
Description	Contains additional information and descriptions of the *personnel actual property* definition.	“Level of polishing skill certification actually used for the widget polisher.”
Value	The value or set of values for the associated property. For example: Apprentice, Journeyman, Master.	Master
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of personnel resources used in the parent segment, if applicable.	.25
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Hour

4.11.7 Equipment actual

Table 80 defines the attributes for *equipment actual* objects.

Table 80 — Equipment actual attributes

Attribute Name	Description	Example
Equipment Class	Identifies the associated *equipment class* or set of *equipment classes* actually used for a specific *segment response*.	Widget Polishing Machine
Equipment	Identifies the associated *equipment* or set of *equipment* actually used for a specific *segment response*. Typically either *equipment class* or *equipment* is specified, but not both.	WPM-20
Description	Contains additional information and descriptions of the *equipment actual.*	“Specifics the actual machine used for this production request.”
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable. Applies to each member of the *equipment* and *equipment class* sets.	.05
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours

4.11.8 Equipment actual property

Table 81 defines the attributes for *equipment actual property* objects.

Table 81 — Equipment actual property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *equipment property* or *equipment class property* for a specific *segment response*.	Polisher Type
Description	Contains additional information and descriptions of the *equipment actual property* definition.	“Actual polisher used for this production segment.”
Value	The value or set of values for the associated property. For example: Wet, Dry.	Dry
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of equipment resources used in parent segment, if applicable	.05
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Machine Hours

4.11.9 Material produced actual

Table 82 defines the attributes for *material produced actual* objects.

Table 82 — Material produced actual attributes

Attribute Name	Description	Example
Material Class	Identifies the associated *material class* or set of *material classes* actually made for a specific *segment response*.*	Widgets
Material Definition	Identifies the associated *material definition* or set of *material definitions* actually made for a specific *segment response*.*	Export Quality Widgets
Material Lot	Identifies the associated *material lot* or set of *material lots* actually made for a specific *segment response*.*	BWLOT-2282
Material Sublot	Identifies the associated *material sublot* or set of *material sublots* actually made for a specific *segment response*.*	BWLOT-2282-A
Description	Contains additional information and descriptions of the *material produced actual*.	“Master Segment - Number of Widgets actually produced.”
Location	Identifies the actual location of the produced material, if applicable.	Finished Goods Inventory
Quantity	Specifies the amount of material produced by the parent segment. Applies to each member of the *material lot*, *materials definition*, or *material class* sets.	1498
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Units

* Typically a *material class, material definition, material lot,* or *material sublot* is specified.

4.11.10 Material produced actual property

Table 83 defines the attributes for *material produced actual property* objects.

Table 83 — Material produced actual property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *material property* or *material class property* for a specific *segment response*.	Color
Description	Contains additional information and descriptions of the *material produced actual property* definition.	“Defines the color actually produced, in the polishing segment.”
Value	The value or set of values for the associated property. For example: Red, Orange, Yellow, Green, Blue, Indigo, Violet.	Red
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	Color
Quantity	Specifies the amount of material produced by the parent segment. Applies to each member of the *material lot*, *materials definition*, or *material class* sets.	1002
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Units

4.11.11 Material consumed actual

Table 84 defines the attributes for *material consumed actual* objects.

Table 84 — Material consumed actual attributes

Attribute Name	Description	Example
Material Class	Identifies the associated *material class* or set of *material classes* actually used for a specific *segment response*. *	Paint
Material Definition	Identifies the associated *material definition* or set of *material definitions* actually used for a specific *segment response*. *	Red Paint
Material Lot	Identifies the associated *material lot* or set of *material lots* actually used for a specific *segment response*. *	GP-RED-42
Material Sublot	Identifies the associated *material sublot* or set of *material sublots* actually made for a specific *segment response*.*	GP-RED-42-A
Description	Contains additional information and descriptions of the *material consumed actual.*	“Paint to be used to finish the widgets in the polishing segment.”
Location	Identifies location from which the material was consumed.	Maintenance Crib
Quantity	Specifies the amount of material resources consumed by the parent segment, if applicable. Applies to each member of the *material lot*, *material sublot*, *material definition*, or *material class* sets.	12
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	355 ml Cans

* Typically a *material class, material definition, material lot,* or *material sublot* is specified.

4.11.12 Material consumed actual property

Table 85 defines the attributes for *material consumed actual property* objects.

Table 85 — Material consumed actual property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *material property* or *material class property* for a specific *segment response*.	Gloss
Description	Contains additional information and descriptions of the *material consumed actual property* definition.	“Defines the type of paint used in production.”
Value	The value or set of values for the associated property. For example: Flat, Satin, High Gloss.	High Gloss
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	[not applicable]
Quantity	Specifies the amount of material resources consumed by the parent segment, if applicable.	4
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	355 ml Cans

4.11.13 Consumables actual

Table 86 defines the attributes for *consumable actual* objects.

Table 86 — Consumables actual attributes

Attribute Name	Description	Examples
Material Class	Identifies the associated *material class* or set of *material classes* actually used for a specific *segment response*. *	Tape
Material Definition	Identifies the associated *material definition* or set of *material definitions* actually used for a specific *segment response*. *	Masking Tape
Description	Contains additional information and descriptions of the *consumable actual*.	“Usage of masking tape for polishing segment.”
Location	Identification of the location from which the consumable was obtained, if applicable.	Shop Floor
Quantity	Specifies the amount of material resources consumed by the parent segment, if applicable. Applies to each member of the *material definition* or *material class* sets.	2.8
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Meters

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

4.11.14 Consumables actual property

Table 87 defines the attributes for *consumables actual property* objects.

Table 87 — Consumables actual property attributes

Attribute Name	Description	Example
Property Name	An identification of the associated *material property* or *material class property* for a specific *segment response*.	Tape Width
Description	Contains additional information and descriptions of the *consumable actual property* definition.	“Width of the tape used in production.”
Value	The value or set of values for the associated property.	10
Value Unit of Measure	The unit of measure of the associated property value, if applicable.	mm
Quantity	Specifies the amount of material resources consumed by the parent segment, if applicable.	1.2
Quantity Unit of Measure	Identifies the unit of measure of the quantity, if applicable.	Meters

5 Completeness, compliance and conformance

5.1 Completeness

The number of object models and objects supported, as defined in Part 1, clause 7 and in Part 2, clause 4, shall determine the degree of completeness of a specification or application.

5.2 Compliance

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

a) The use of the terminology defined in Part 1, clause 7

b) The use of the attributes for each supported object

c) A statement of the degree to which they then conform partially or totally to definitions and attribute names

In the event of partial compliance, areas of noncompliance shall be explicitly identified.

5.3 Conformance

Any assessment of the degree of conformance of an application shall be qualified by the following:

a) Documentation of the object models and objects, as listed in Table 88 through Table 96, conformed to

b) Documentation of the attributes conformed to

c) A statement of the mapping of the application’s attributes and object names to the objects and attributes listed in Part 2

In the event of partial conformance, areas of nonconformance shall be explicitly identified.

Table 88 — Production capability model objects

Production capability
Personnel capability
Personnel capability property
Equipment capability
Equipment capability property
Material capability
Material capability property

Table 89 — Process segment capability model objects

Process segment capability
Segment personnel capability
Segment personnel capability property
Segment equipment capability
Segment equipment capability property
Segment material capability
Segment material capability property

Table 90 — Personnel model objects

Person
Person property
Personnel class
Personnel class property
Qualification test specification
Qualification test result

Table 91 — Equipment model objects

Equipment
Equipment property
Equipment class
Equipment class property
Equipment capability test specification
Equipment capability test result
Maintenance request
Maintenance work order
Maintenance response

Table 92 — Material model objects

Material class
Material class property
Material definition
Material definition property
Material lot
Material lot property
Material sublot
QA test specification
QA test result

Table 93 — Process segment model objects

Process segment
Personnel segment specification
Personnel segment specification property
Equipment segment specification
Equipment segment specification property
Material segment specification
Material segment specification property

Table 94 — Product definition information object models

Product production rule
Manufacturing bill
Product segment
Product parameter
Personnel specification
Personnel specification property
Equipment specification
Equipment specification property
Material specification
Material specification property

Table 95 — Production schedule model objects

Production schedule
Production request
Segment requirement
Production parameter
Personnel requirement
Personnel requirement property
Equipment requirement
Equipment requirement property
Material produced requirement
Material produced requirement property
Material consumed requirement
Material consumed requirement property
Consumable expected
Consumable expected property

Table 96 — Production performance object models

Production performance
Production response
Segment response
Production data
Personnel actual
Personnel actual property
Equipment actual
Equipment actual property
Material produced actual
Material produced actual property
Material consumed actual
Material consumed actual property
Consumables actual
Consumables actual property

Annex A — (informative) — Examples

A.1 Introduction

The following sections contain example data sets, based on the models in the Part 1 standard, and using the attributes defined in this Part 2 standard.

A.2 Material model example

This is a simplified example of material information that may be used in the food processing industry. The example defines shared information about a material class (Pork), a material definition (Pork 80% Lean), a material lot, and a material sublot. In a full example there may be multiple material class and material definitions information sets that are shared, with lot and sublot 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

A.3 Personnel model example

This is a simplified example of personnel information that might be used in the petrochemical processing industry. The example defines 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

A.4 Equipment model example

This is a simplified example of equipment information that might be used in the electronic board assembly industry.

Equipment Class

ID - Board Fabrication Line
Description -

Equipment class property

ID - Board size
Description - The maximum size of PC board supported on this line
Value -
Unit of Measure - mm

ID - Input queue size
Description - The maximum number of boards allowed in the input queue
Value -
Unit of Measure -

ID - Wave solder temperature variability
Description - the variability in the solder temperature
Value -
Unit of Measure - Degrees C

Equipment Capability Test Specification
ID - WS-1985-A23
Description - Test to determine solder temperature variation.
Version - 1985-09-A

Equipment

ID - East Production Area
Description - East building production line, Factory 52

ID - East line 1
Description - Pager board assembly line, East building, line 1

Equipment Property

ID - Board size
Value - 10

ID - Input queue size
Value - 25

ID - Wave solder temperature variability
Description - Normal plus or minus temperature variability
Value - 3.5
Units of Measure - Degrees C

Equipment Capability Test Result

ID - WS-1985-A23
Description - Test to determine actual solder temperature variation.
Result - 3.5
Expiration Date - 2000-06-15

ID - East line 2
Description - Pager board assembly line, East building, line 2

Equipment Property

ID - Board size
Value - 5

ID - Input queue size
Value - 50

ID - Wave solder temperature tolerance
Description - Normal plus or minus temperature variability
Value - 1.5
Units of Measure - Degrees C

Equipment Capability Test Result

ID - WS-1985-A23
Description - Test to determine actual solder temperature variation.
Result - 1.5
Expiration Date - 2000-05-01

A.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, defined for 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

Property Name – Viscosity
Value – 104
Unit of Measure - cp (centipoise)

Material capability property

Property Name - Entry Temperature
Value – 30
Unit of Measure - Deg C

Material capability property

Property Name - Ground Temperature
Value – 18
Unit of Measure - Deg C

A.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
Published Date - 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

Property Name - Average Viscosity
Value – 103
Unit of Measure - cp (centipoise)

Material produced actual property

Property Name - Entry Temperature
Value - 32.3
Unit of Measure - Deg C

Annex B — (informative) – Expected use

B.1 Introduction

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

B.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* define the material inflow into production, or can it be defined in the *product production rule*?

Answer:

There are no attributes in the *Product Segment - Material Specification*, or the *Process Segment - Material Segment Specification* that define 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* (e.g. 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.

B.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?

For 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:

Part 2 does not model the object relationships in Part 1, so this is a matter of implementation. The most common approach to this problem seems to be to define 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 define 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.

B.4 Process segments vs product segments

Question:

What is the difference between process segments and product segments?

Answer:

A *process segment* defines a production activity and what resources are needed to execute the activity, at the level of detail required for planning or costing. For 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* defines what resources are needed to make a product, at the level of detail required for planning or costing. For 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... 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 defining the resources needed for production. In the continuous industries, this usually corresponds to scheduled/planned operations within production units. For 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. For 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. For 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. *Product 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 define specific characteristics for each product is possible.

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

B.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 done on purpose, because the ISA-SP95 committee had examples for both cases. For 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).

B.6 How class name and property names are used to identify elements

Question:

The object models all follow the same pattern of class name, with an optional property name. 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 defined 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. For example, it may define 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. For example, a *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 definition, and multiple property definitions (e.g., Master, Standard, and Junior operators) each with their own property definition. The left part of Figure B-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.

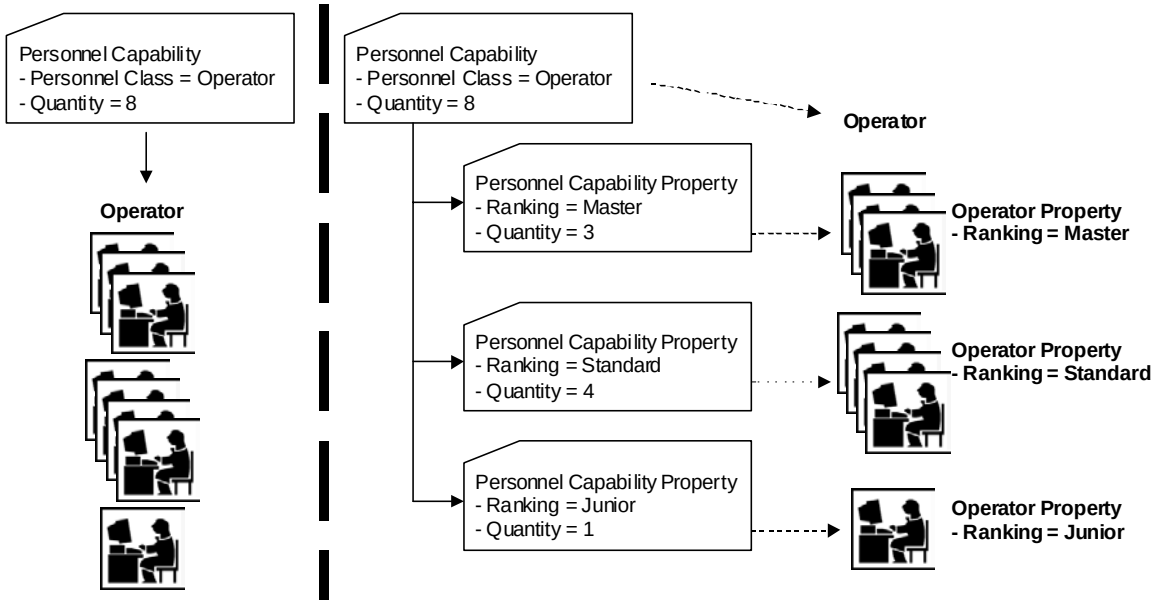


Figure B-1 — Class and property names used to identify elements

This concept applies to the following models:

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

B.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 defined 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 define overlapping subsets of a capability, then the same capability may be double scheduled unless this situation is recognized. Figure B-2 shows an example where a property of *ReactorType* defines 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.

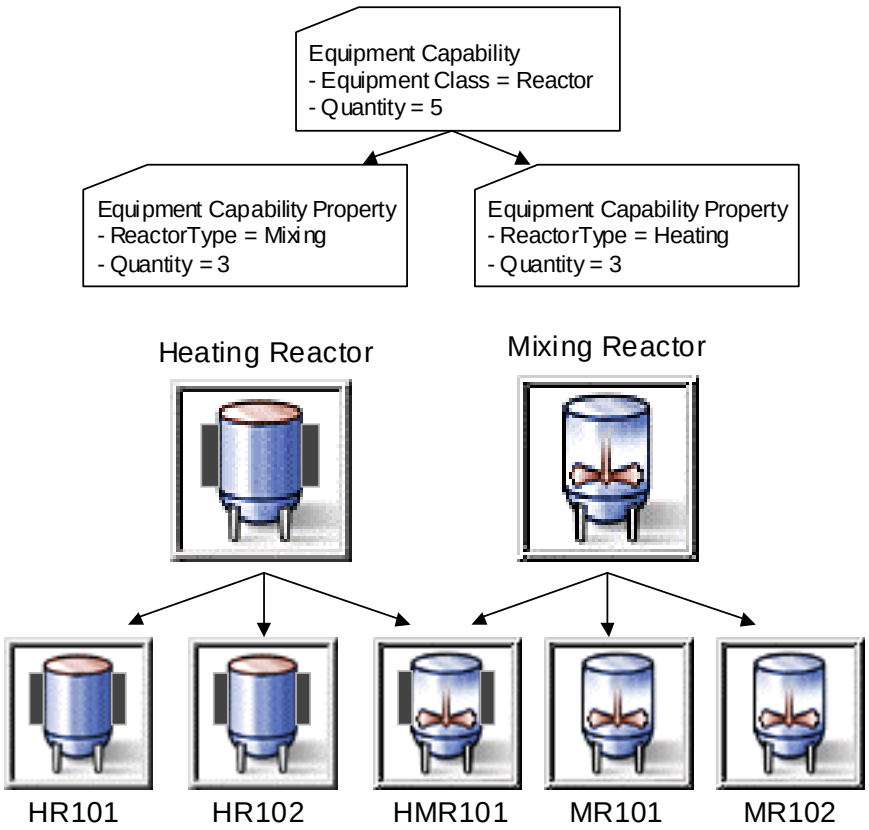


Figure B-2 — A property defining overlapping subsets of the capability

B.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 B-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 B-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 B-3.

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

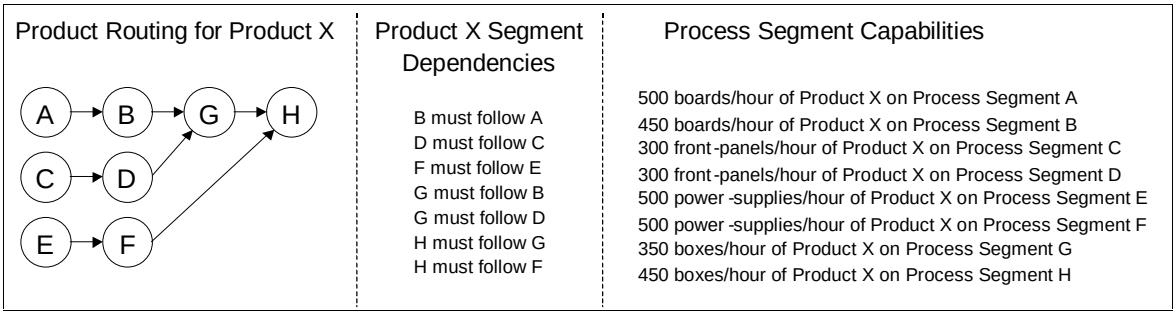
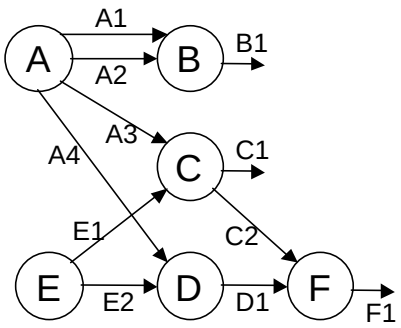


Figure B-3 — Routing for a product

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

Routings and Material Dependencies



Process Segment

Process Segment A
- produces material
- produces material
- produces material
- produces material

Process Segment B
- consumes material A1
- consumes material A2
- produces material B1

Process Segment C
- consumes material A3
- consumes material E1
- produces material C1
- produces material C2

Process Segment D
- consumes material A4
- consumes material E2
- produces material D1

Process Segment E
- produces material E1
- produces material E2

Process Segment F
- consumes material C2
- consumes material D1
- produces material F1

Process Segment Dependencies

B must follow A
C must follow A
C must follow E
D must follow A
F must follow C
F must follow D

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

B.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 B-5 defines 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 define 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 B-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.

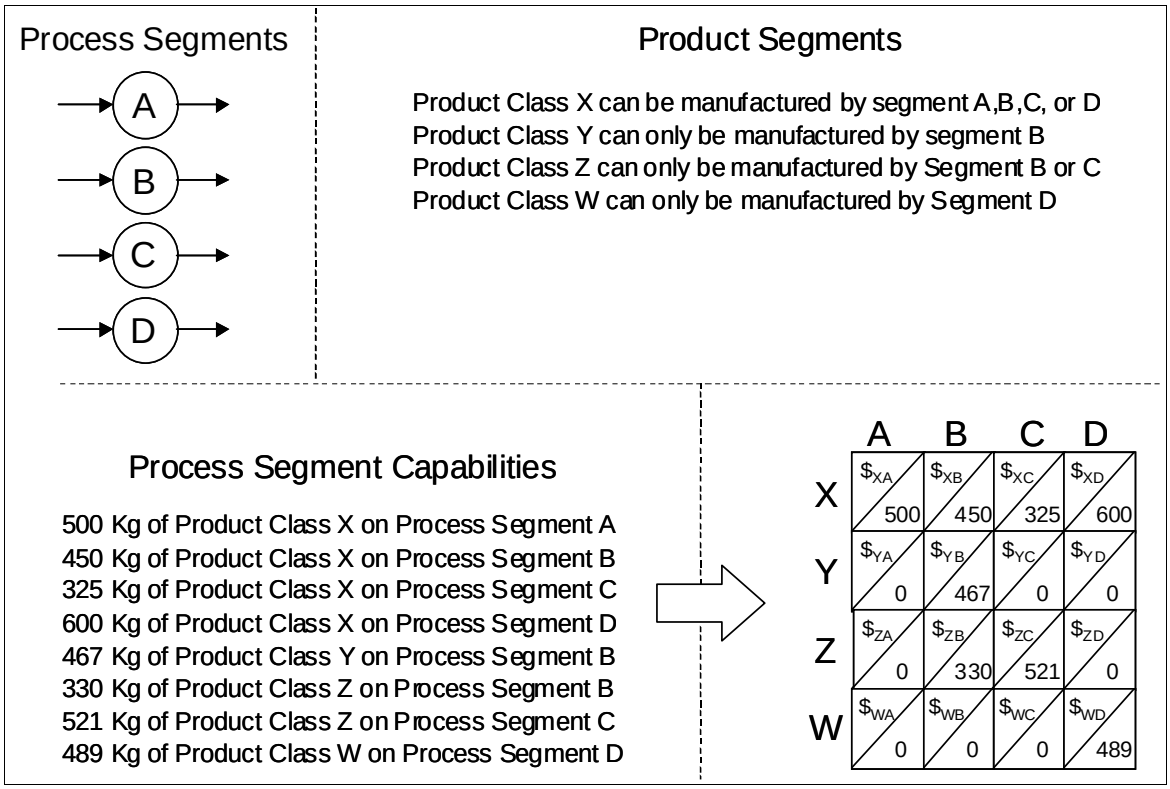


Figure B-5 — Product and process capability relationships

B.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 define the dependency. These may be simple dependencies, such as

a) one segment follows another segment;

b) one segment can not 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; or

g) one segment starts any time after another segment ends.

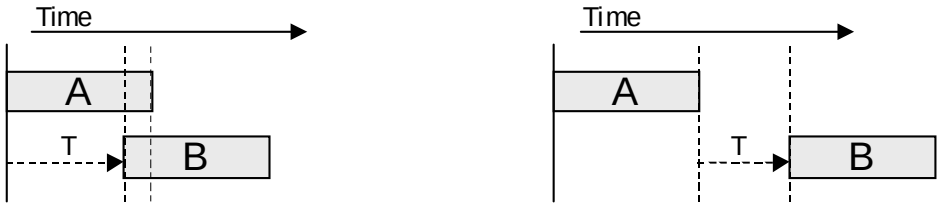
These dependencies may define physical constraints (because of production line layout), or constraints based on safety (such as prohibiting a “water add” after an “acid fill”), or constraints based on the chemical or physical processing required to make a product (bicycle wheels must be assembled before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

More complicated constraints based on timing may also be defined using the *Timing Factor* attribute. For example,

a) the longer a semiconductor wafer is kept unprocessed the more defects are introduced, so there is a maximum delay allowed between segments of production; and

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

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



B may run in parallel to A
Start B at A start
Start B after A start
Start B no later than T time after A start
Start B no earlier than T time after A start

B may not run in parallel to A
Start B at A end
Start B after A end
Start B no later then T time after A end
Start B no earlier than T time after A end

Figure B-6 — Time-based dependencies

B.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 defined 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.

B.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.

B.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 sublot and material produced sublot 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.

B.14 Why the maintenance and QA models are different from the production model

Question:

Why is the maintenance model (*maintenance request*, *maintenance response*) different from the production model (*production schedule* and *production information*)? Can’t maintenance be handled using the production model? Can’t quality assurance test scheduling also be handled by the production model?

Answer:

Part 1 and 2 assume that maintenance scheduling and performance is normally performed as part of manufacturing operations. However, maintenance scheduling may be performed in level 4. In this case it is assumed that only *maintenance requests* and *maintenance responses* cross the level 3-4 boundary. To cover this case only *maintenance requests* and *maintenance responses* are defined in Part 1 and 2.

Beyond the scope of Part 1 and Part 2, a maintenance schedule object may be created that parallels the structure of the production schedule object and consists of a collection of maintenance requests as shown in Figure B-7. Likewise a maintenance performance object may be created that parallels the structure of the production performance object.

Alternatively, segment requests can be used to schedule maintenance activities in a *production schedule* and segment responses can be used to represent maintenance responses in a *production performance*.

A similar model could be used for quality assurance test schedules and performances.

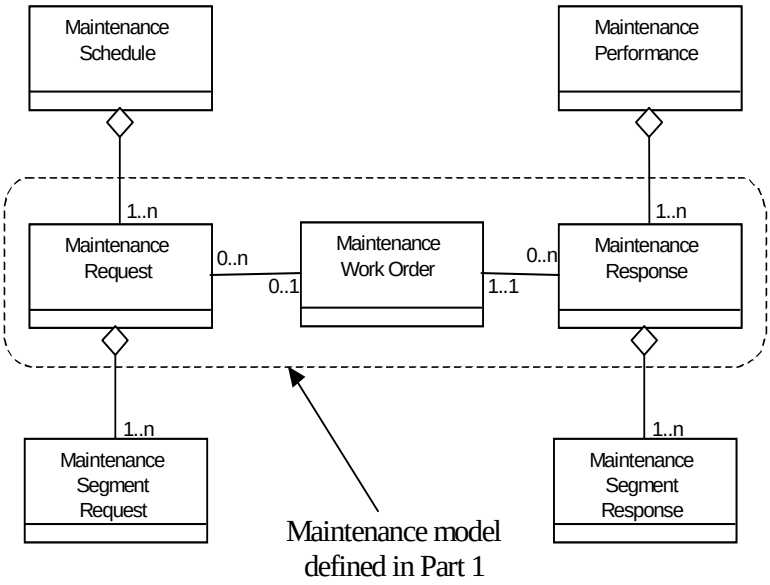


Figure B-7 — Maintenance schedule and performance model

Annex C (informative) – Logical information flows

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 (for example, property names). 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. 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 C-1 illustrates some possible logical information flows between enterprise systems and manufacturing control systems.

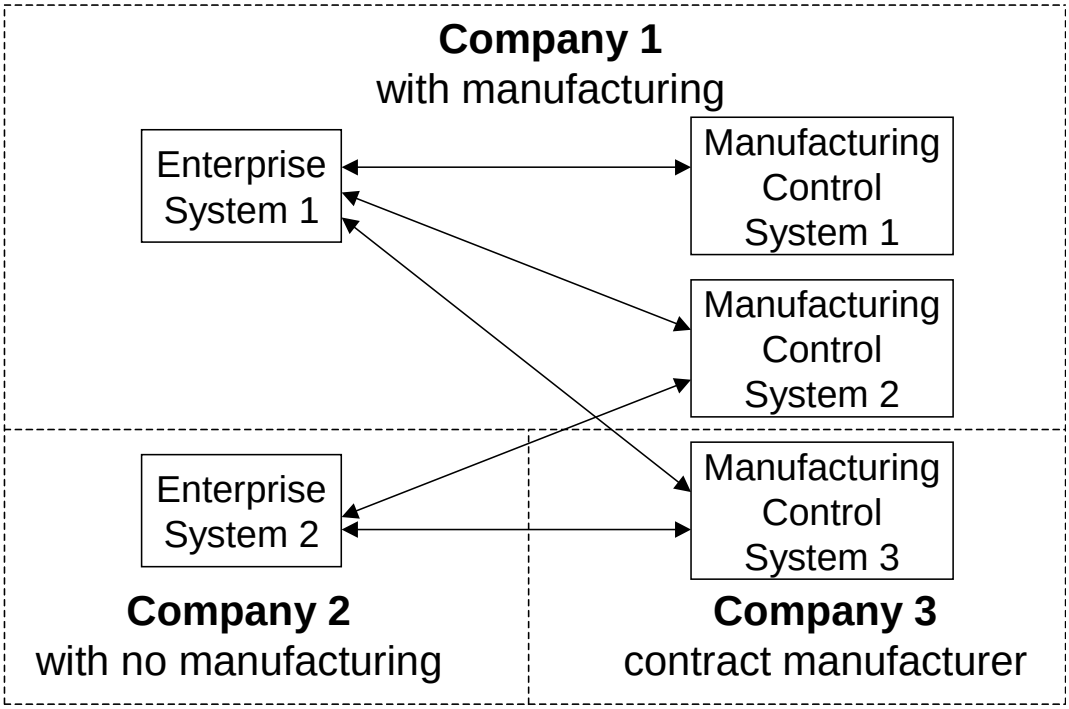


Figure C-1 — Enterprise to manufacturing system logical information flows

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 define different communication protocols and will often require additional attributes and objects. For 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. Examples of the many-to-many exchanges include multiple maintenance systems or quality systems. Figure C-2 illustrates examples of manufacturing control system connections.

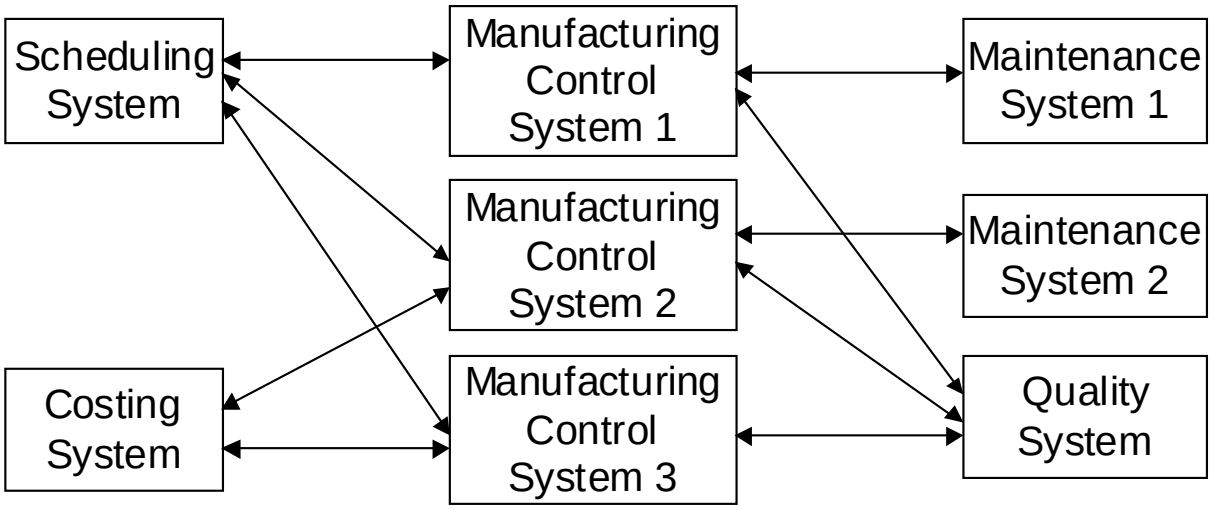


Figure C-2 — Logical information flows among multiple systems

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