# Enterprise - Control System Integration
# Part 4: Object Models and Attributes of Manufacturing Operations Management

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## Contents

## Figures

## Tables

**Enterprise-Control System Integration**

**Part 4: Object Models and Attributes of Manufacturing Operations Management**

## FOREWORD

This standard is Part 4 of a multi-part set of standards that defines the interfaces between enterprise activities and control activities.

Clause 4 is normative. It ...

Clause 5 is normative. It defines ...

Clause 6 is normative. It defines ...

Annex A is informative. It contains a series of questions and answers regarding the use of the standard.

As currently envisioned, ANSI/ISA-95 consists of the following parts under the general title Enterprise/Control System Integration:

- Part 1: Models and terminology
- Part 2: Object models and attributes
- Part 3: Models of manufacturing operations management
- Part 4: Object models and attributes of manufacturing operations management
- Part 5: Business to manufacturing transactions
- Part 6: Manufacturing operations transactions

## INTRODUCTION

This technical specification defines business to object models and attributes of the object models that define some of the information exchanged between functions defined in ISA 95.00.03. The object models and attributes may be used in the design and implementation of interface standards and for interoperability in manufacturing operations management.

**ENTERPRISE/CONTROL SYSTEM INTEGRATION**

**Part 4: Object Models and Attributes of Manufacturing Operations Management**

## 1. Scope

This standard defines object models and object model attributes of some of the information exchanged between and within operations management functions defined in the ISA 95.00.03 standard.

## 2. Normative references

The following normative documents contain provisions, which through reference in this text constitute provisions of this part 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 part of this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid normative documents.

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

— ANSI/ISA 95.00.02-2001, Enterprise/Control System Integration – Part 2: Object Model Attributes

— ISO/IEC 19501-1 Information Technology—Unified Modeling Language (UML)—Part 1: Specification

— IEC/ISO 62264-1, Enterprise/Control System Integration - Part 1: Models and Terminology

## 3. Definitions and abbreviations

For the purposes of this part of this international standard the following apply.

### 3.1 Definitions

#### 3.1.1 Production work segment

#### 3.1.2 Work segment

### 3.2 Abbreviations

## 4. Object models and attributes

### 4.1 Introduction

This clause describes objects models and attributes for the information that may be exchanged between the manufacturing operations categories defined in Part 3. This clause also defines a generic model for exchanged information which may be applied to other instantiations of the generic activity model in Part 3.

### 4.2 Intra-manufacturing operations management information

The activity models in Part 3 define information which may be exchanged with Level 4 activities or which may be exchanged with other Level 3 activities. This information is illustrated in Figure 1 as the information contained within the dotted ellipse. There is additional exchanged information between the Level 3 activities categories, and information exchanged within each information category, as illustrated by the dotted arrow in Figure 1. Critical elements of the additional exchanged information are also defined in this clause.

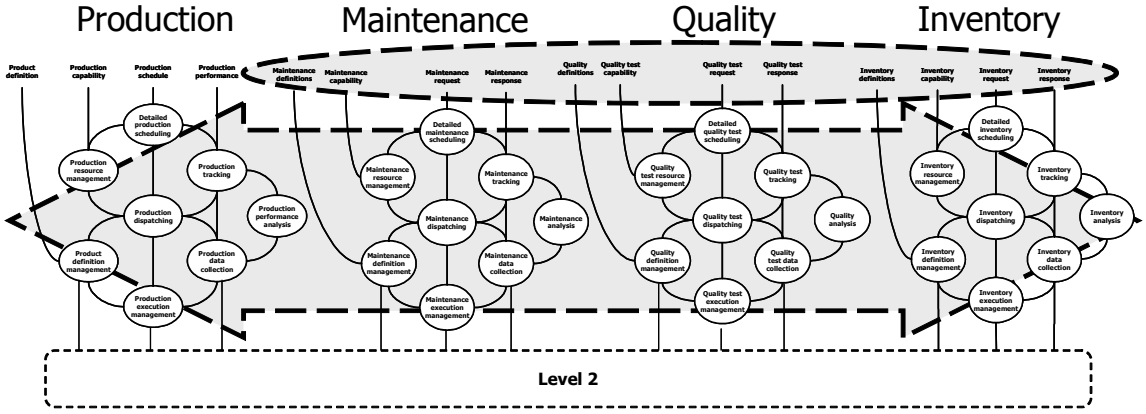



Figure 1 - Main information elements from Part 3

Figure 2 illustrates some of the possible exchanged information between Level 3 activity categories and Level 4 activities. There is also additional information exchanged and the exact information exchanged will be defined the specific business and operations policies, and by the different systems and tools supporting the functions.

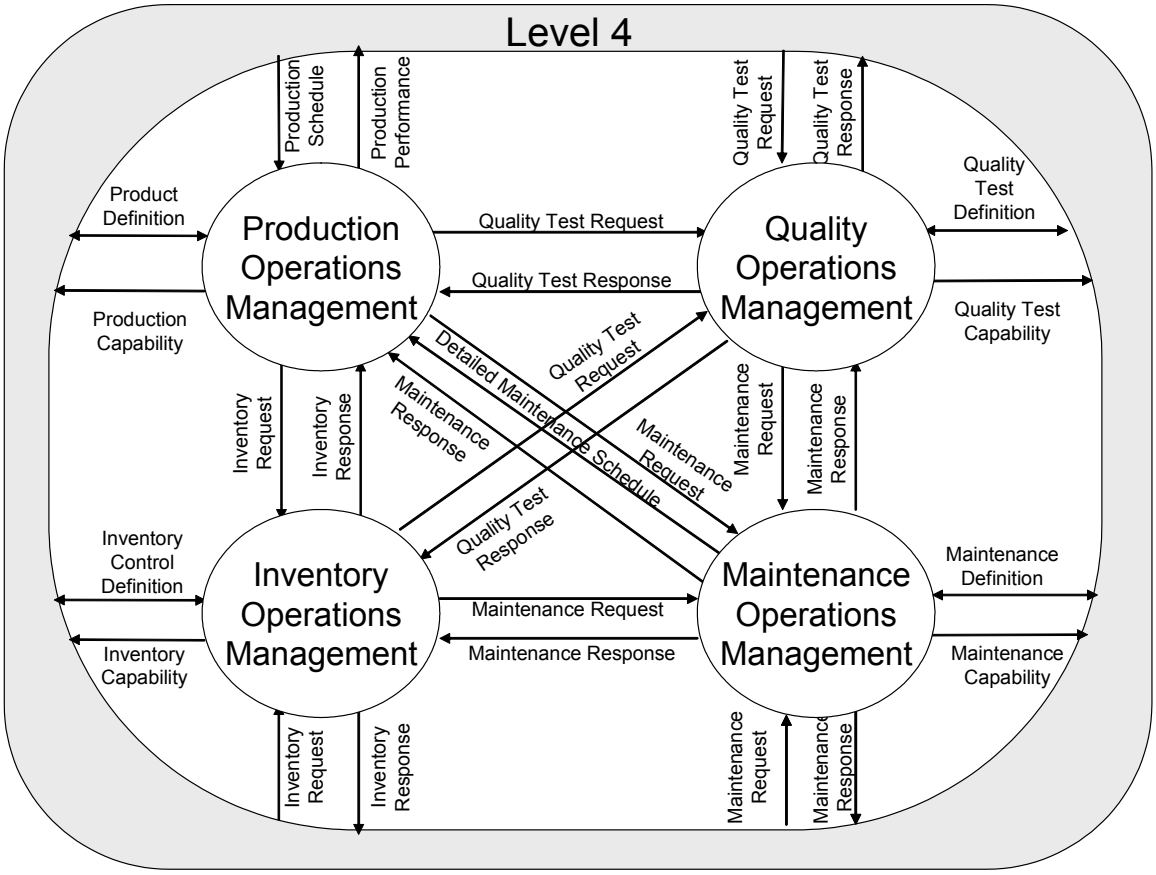



Figure 2 – Sample exchanged information between Level 3 activity categories

The object model includes the definition of attributes for each object. A minimum set of industry-independent information has been given 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.

### 4.3 Extensions to Part 1 and 2 models

The object models in Part 1 were limited in scope to exchanged information between Level 3 and Level 4 activities, and as such were limited in the level of detail. Elements of the Part 1 models are used in the models in this Part. In addition some of the object models in Part 1 are extended and modified to include additional information and objects. These extensions do not change the Level 3-4 exchanged information, but do provide the additional detail and objects required for Level 3 to Level 3 information exchange.

### 4.4 Explanation of tables

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

### 4.4.1 Data types

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

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

Example 2: A date/time value may be represented in ISO standard format in one implementation and in Julian calendar format in another.

Example 3: A relationship may be represented by two fields (type and key) in data base tables or by a specific tag in XML.

### 4.4.2 Presentation of examples

Examples are included with each attribute given. 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 given within a set of braces, {}.

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

# 5. Generic object models and templates

## 5.1 Top level template for exchanged information

### 5.1.1 Top level template model

The top level template data model for exchanged information between Level 3 categories is used as a template to define exchanged information for production operations management, maintenance operations management, quality operations management, and inventory operations management. This model is shown in Figure 3. This generic model is extended for each specific exchanged information sets in later sections.

The template data model is based on the production request, production performance, production capability, and product definition models defined in Part 1. It points out that specific information exchange models can be constructed from the generic model. Part 1 and 2 contains an instantiation of this template for production. This part contains instantiations for maintenance operations management, quality operations management, and inventory operations management.

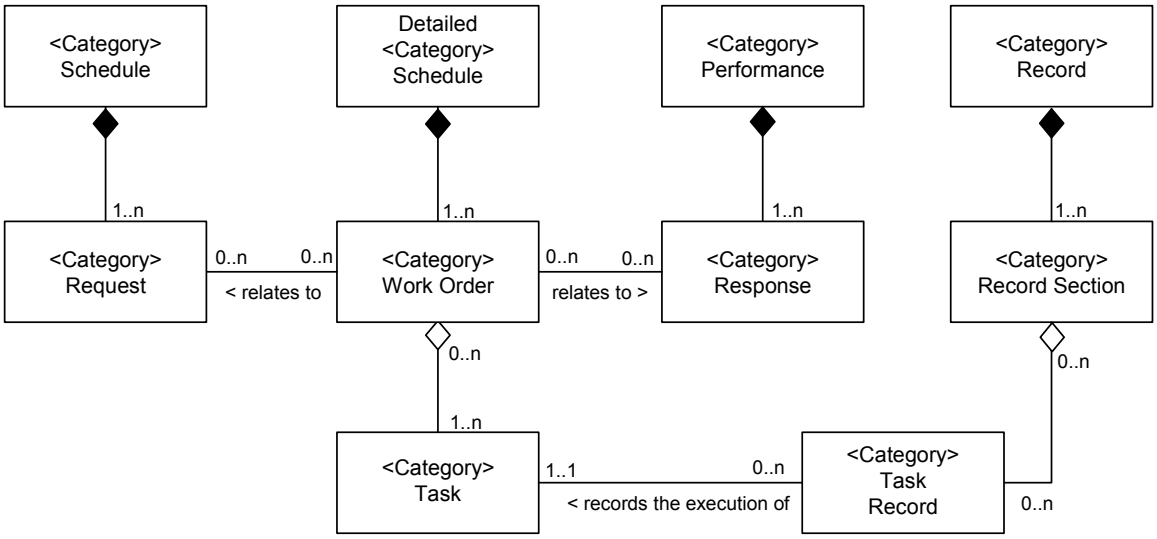



Figure 3 – Top level template for exchanged Level 3 category information

### 5.1.2 Template objects

The template in Figure 3 depicts objects. These are:

1. Category schedule – This defines a high level schedule for the activities within a category. A category schedule is made up of category requests.

   Example: A high level maintenance schedule or a high level quality test schedule.

2. Category request – This defines an element of the schedule, relating to a well defined aspect of a category.

Example: A production request for the production of a specific product.

3. Detailed category schedule – This defines a detailed schedule for the activities within a category. A detailed category schedule is made up of category work orders.
4. Category work order – This defines an element of a detailed schedule within a category. A category work order is made up of category work segments.
5. Category task – This defines an element of work performed in the category. Elements of work may be defined as part of a category work order, or may be defined independent of the work order.
6. Category performance – This defines a report on the performance of the category activity, it may relate to a category schedule. A category performance is made up of category responses.
7. Category response – This defines an element of a category performance that may relate to a category request element.
8. Category task report – This defines a collection of information related to the execution of a category task. It records information on the events and activities associated with the task.

   Example: This information could include the work task execution information, specific equipment information, operator comments, batch or work task related alarms, and elements related to the definition of the work task, such as a control recipe identification, SOP identification, or assembly step identification,

9. Category record – This defines a subset of the category task report information that is required to support one or more business processes.
10. Category record section – This defines an element of a category record.

### 5.1.3 Template relationships

The template in Figure 3 depicts relationships between objects. These relationships are:

1. Category Work Order to Category Request – A category work order may be related to a category request. There may be zero or more work orders associated with a request, or zero or more requests associated with a work order. The relationship is usually defined by the specific rules required to partition and coordinate the production request.
2. Category Work Order to Category Response – …
3. Category Task Record to Category Task - …

## 5.2 Category schedule template

### 5.2.1 Schedule template

Figure 4 shows the category schedule template. The gray boxes in Figure 4 are defined in Part 1 and Part 2 of this standard. A work segment requirement corresponds to a defined work segment. A work segment requirement may contain work parameters (general information which does not fall into another object), personnel requirements, equipment requirements, material produced requirement, material consumed requirement, and consumables expected. Each instantiation of the template may use, remove, or replace any of the elements under a work segment requirement.

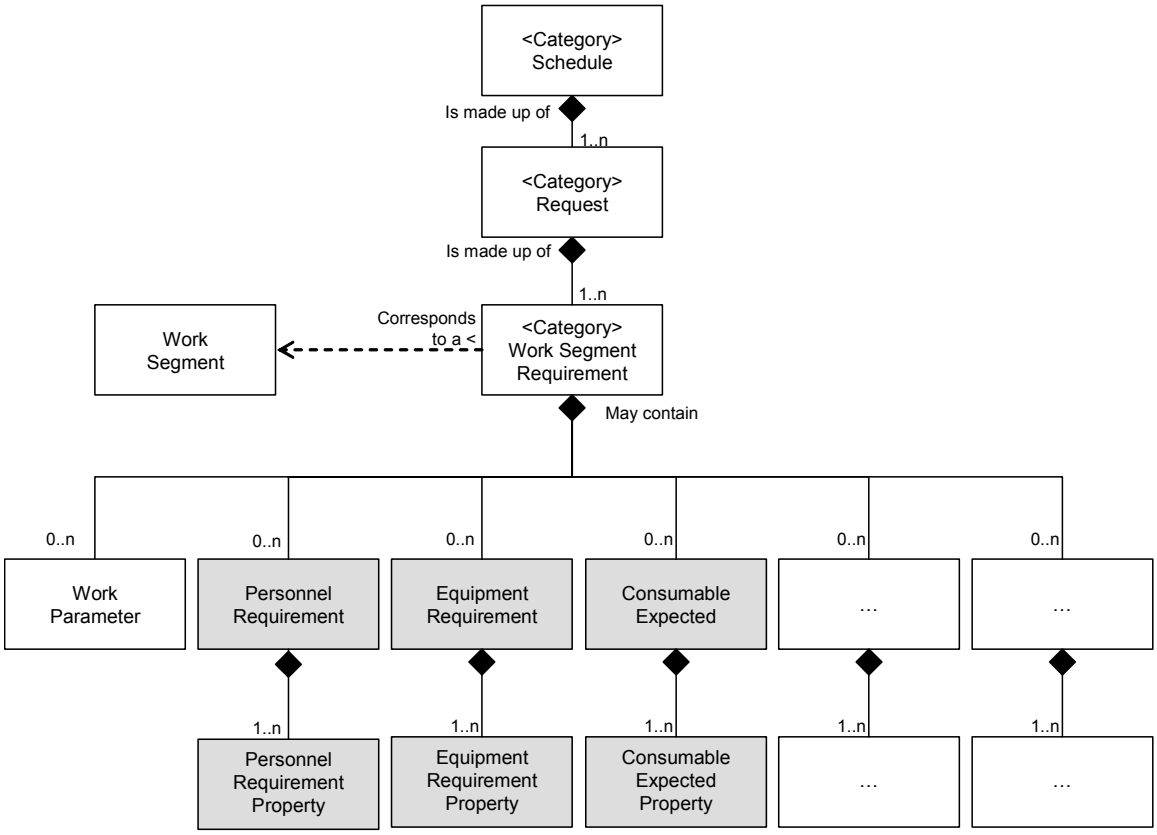



Figure 4 - Category schedule template

### 5.2.2 Schedule template objects

### 5.2.3 Schedule template relationships

## 5.3 Category performance template

### 5.3.1 Performance template

Figure 5 shows the category performance template. A work segment response corresponds to a defined work segment. A work segment response may contain work data (general information which does not fall into another object), personnel actual, equipment actual, material produced actual, material consumed actual, and consumables actual. Each instantiation of the template may use, remove, or replace any of the elements under a work segment response. The gray boxes in Figure 5 are defined in Part 1 and Part 2 of this standard.

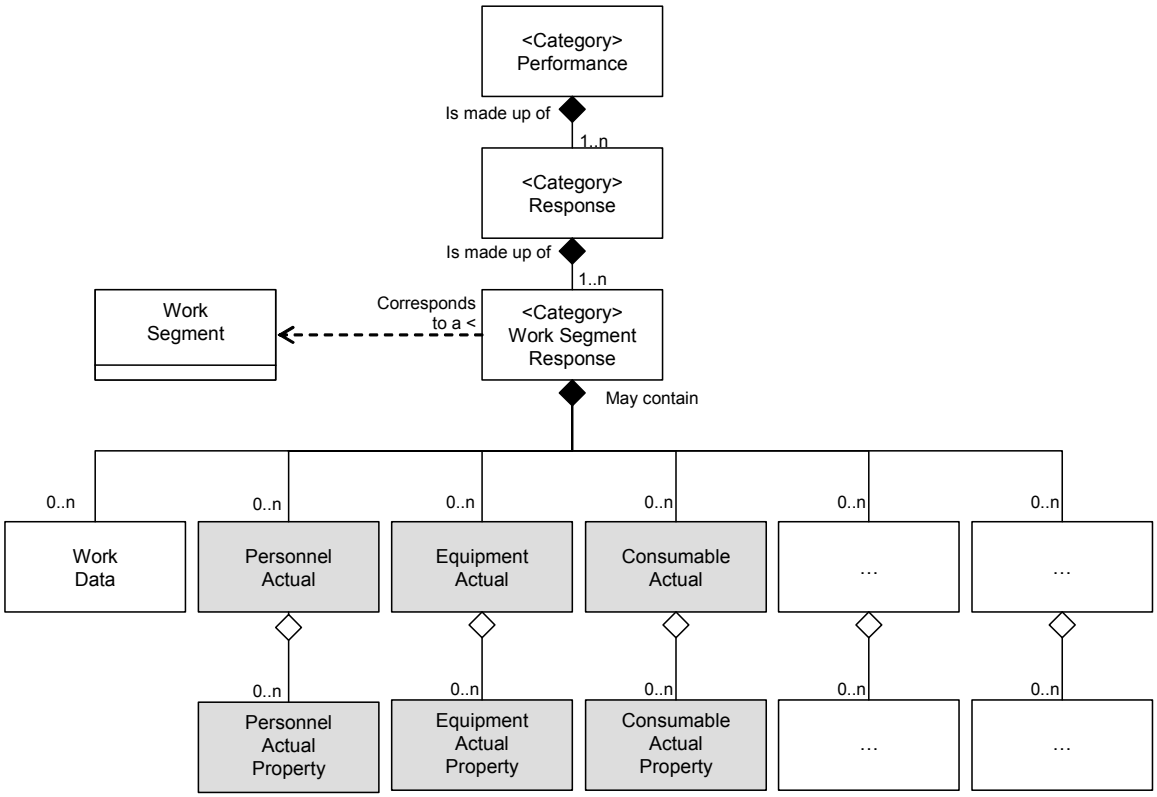



Figure 5 - Category performance template

### 5.3.2 Performance template objects

### 5.3.3 Performance template relationships

## 6. Common and extended object models

### 6.1 Introduction

Some of the models defined in Part 1 are extended to support the requirements for Level 3 information exchange. In addition there are additional objects defined for Level 3 information exchange which are normally not visible for Level 3-4 information exchange.

### 6.2 Work segments

Process and product segments are the business view of the production process. This may not directly relate to the actual physical segmentation of work done to produce products. A Work Segment is defined as unit of operational activity that uses specific production resources to accomplish a physical segment of production. This may include the definition of the personnel

resources, equipment resources, and material specifications required to carry out the segment of production.

A work segment may be composed of nested work segments, such as build, rework, repair, and retest steps in a main work segment.

Work segments may be related to other work segments through an execution dependency, such as one segment must complete before the next segment starts. See Part 2 of this standard, Clause …

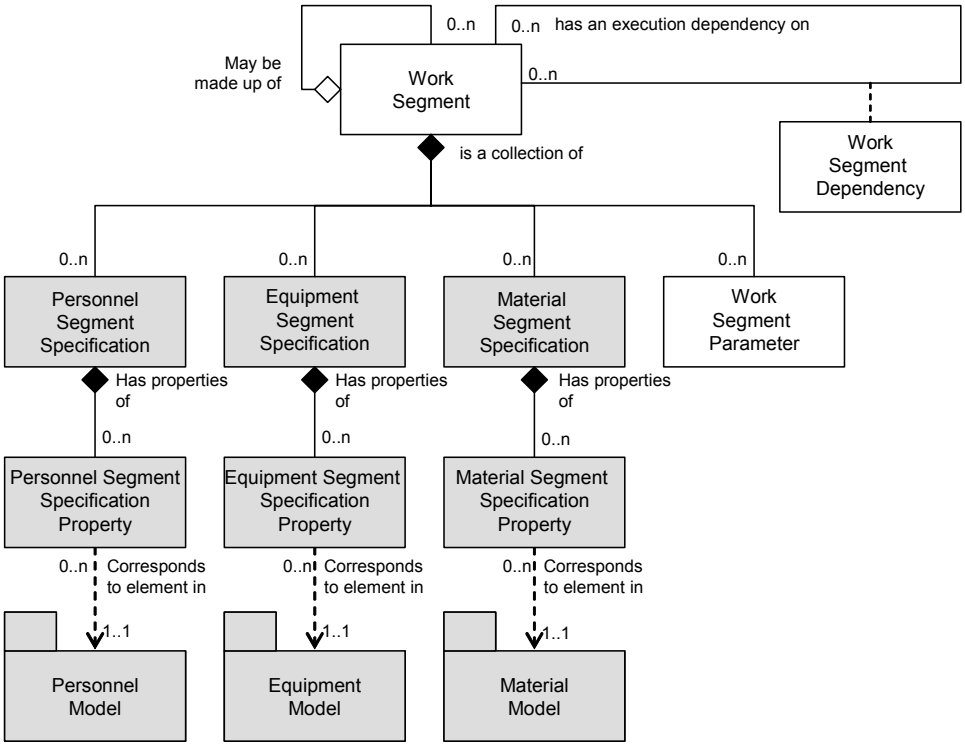



Figure 6 - Work segment object model

### 6.3 Asset model

There is a need to differentiate the logical use of a piece of equipment (its role) from the actual equipment. The equipment model defined in this standard defines equipment as the role the equipment is performing, such as a production unit, work cell, or storage module. The asset model contains information about the physical piece of equipment, usually tracked as a physical asset within the enterprise with a specific serial number. An object in the equipment model defines a role for the equipment, and object in the asset model defines the physical ID and properties of a piece of equipment.

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

While assets have Level 4 significance, usually because they have an economic value, this part of the standard focuses on the Level 3 significance of the asset. The asset model defines a Maintenance Asset as a representation of a physical piece of equipment. Maintenance work requests, work orders, and responses, are made against the physical equipment. This is additional detail than the Level 3-4 exchanged information model defined in Part 1, in which the maintenance information was associated with the role the equipment performed.

Example: A maintenance request may be made against a work cell or unit, but the actual work performed is done on the physical equipment that performs the role, and which make up the work cell or unit.

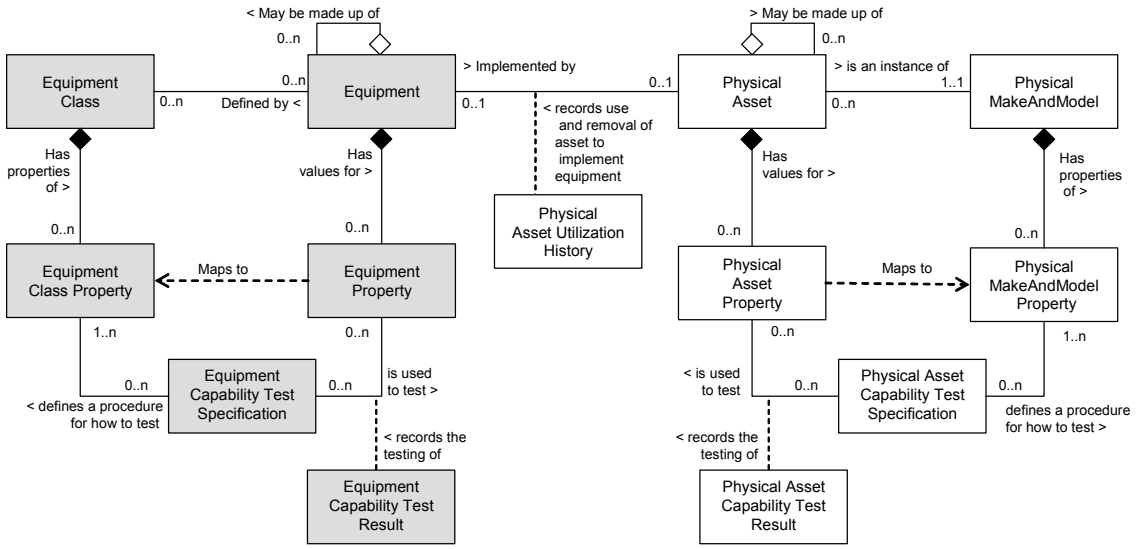



Figure 7 - Equipment and asset

*A MIMOSA Asset maps to a S95 Physical Asset object*

*A MIMOSA Asset Utilization History maps to a S95 Physical Asset Utilization History object*

*A MIMOSA Segment maps to a S95 Equipment object*

*A MIMOSA Network maps to a S95 Resource View object*

*A MIMOSA Model maps to a S95 Physical MakeAndModel object*

*A MIMOSA Agent would map to a S95 attribute or property, where needed*

## 6.4 Test sample object model

**EDITOR'S NOTE: COMMITTEE DISCUSSIONS INDICATED THAT THERE MAY BE ADDITIONAL MODELS REQUIRED FOR THE OTHER AREAS, SUCH AS A MODEL FOR SAMPLES AND TESTS FOR QUALITY OPERATIONS AND CONTAINERS AND VESSELS FOR INVENTORY OPERATIONS. SEE QUALITY**

## 6.5 Container and vessel object model

## 6.6 Product capability model

Detailed production scheduling requires information about what capability is available for specific products. This information augments the Process Capability model defined in Part 1 and is specific to specific products.

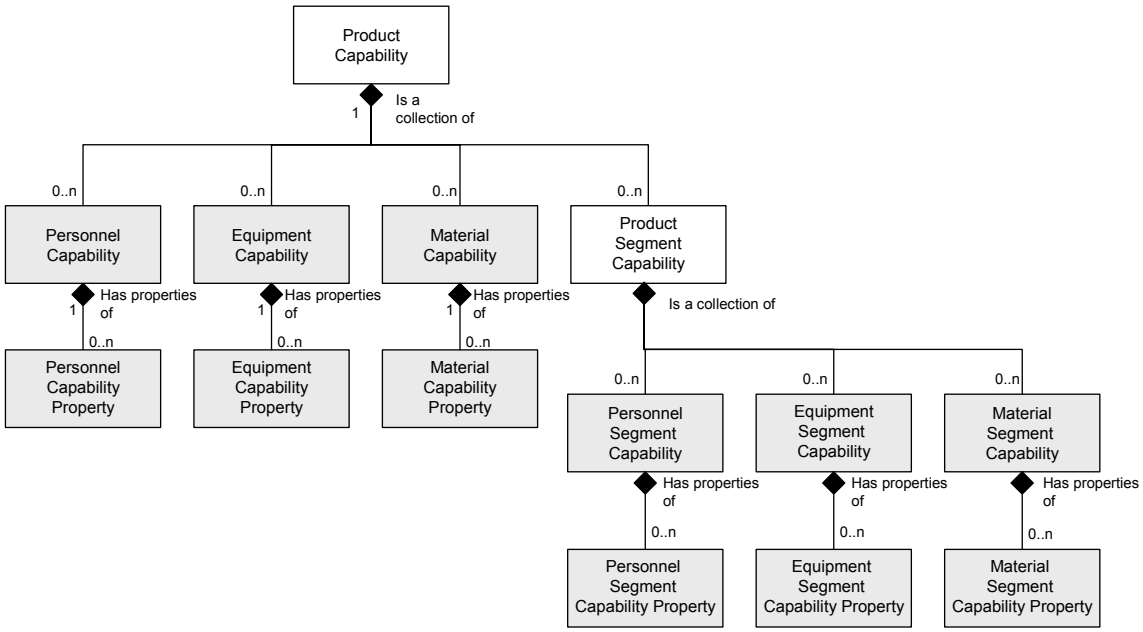
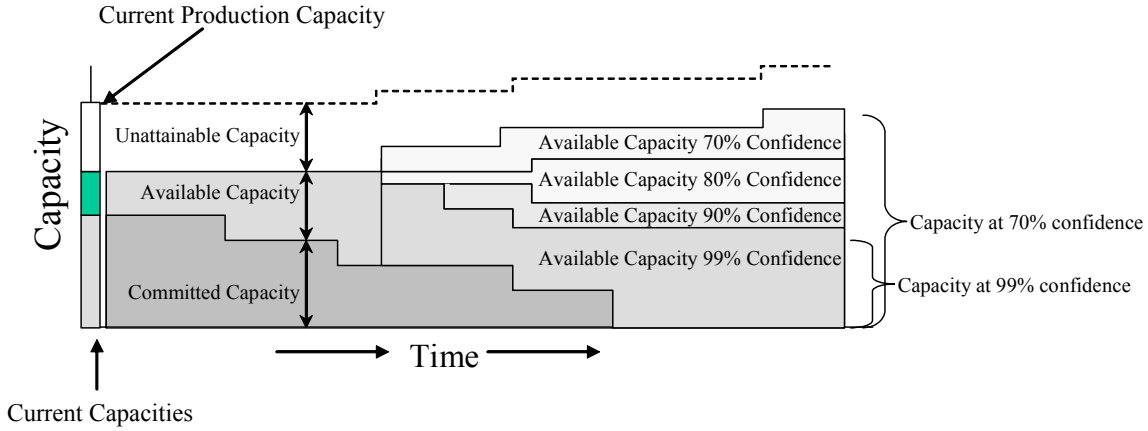



Figure 8 - Product capability model

## 6.7 Capability confidence

This would extend the capability model to include definitions of the confidence of a capability.



### 6.8 KPI model

One of the outputs from the Level 3 analysis activities are KPIs (Key Performance Indicators). These may need to be exchanged between Level 3 activities, and made visible to Level 4 activities.

### 6.9 Production capability utilization information

#### 6.9.1 Production capacity utilization types

The production capability utilization information is the collection of historical information about the utilization of resources. This is made up of information about the utilization of equipment, material, personnel, and process segments.

Production capacity utilization is depicted in Figure 1.

a) Utilized capacity defines resources that were used in production of products within acceptable quality limits.

b) Unused capacity defines resource capacity that was not used in production.

c) Unused capacity may have multiple components, or reasons for the unused capacity, as depicted in Figure 2.

   Example: The reason may be lack of demand, production of unacceptable quality product, or unavailability due to equipment failure or unplanned maintenance.

d) The maximum available production capacity utilization is the capability that was available for use in production.

   Example: Maximum available production capacity utilization may be calculated from the best capacity utilization achieved over some recent period of time.

e) The maximum available production capacity may have changed over time as equipment, material, and personnel capability is added, modified, or removed.

   Example: Maximum available production capacity utilization may change over time as equipment or material (catalysts) age. In Figure 1 the maximum capacity is shown as degrading over time, then being reset due to equipment cleaning or catalyst recharge.

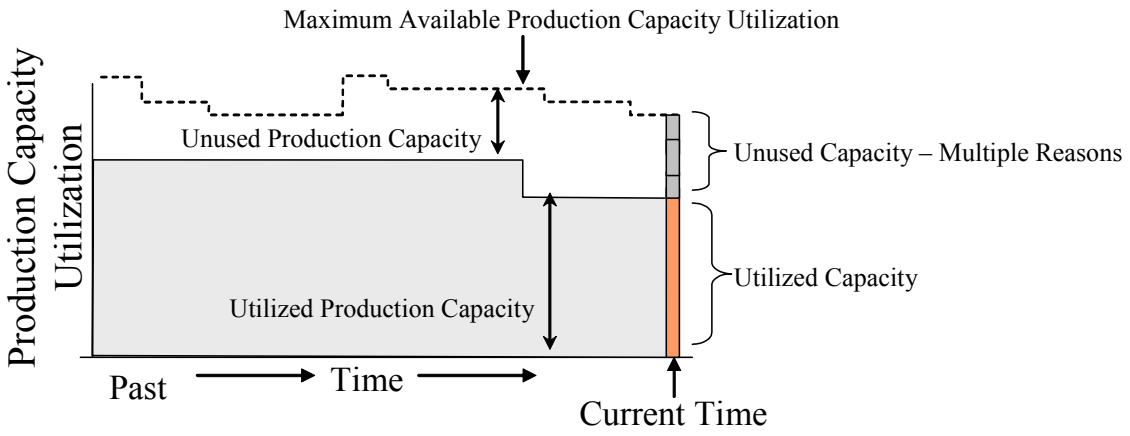



**Figure 9 – Past production capacity utilization**

The production capacity utilization model is designed to capture the type of information illustrated in Figure 10. The information is scoped to a specific element in the equipment hierarchy (a production line, process cell, unit, work cell, etc.). The production segment capacity utilization model can be used to document utilization in the execution of specific process segments.

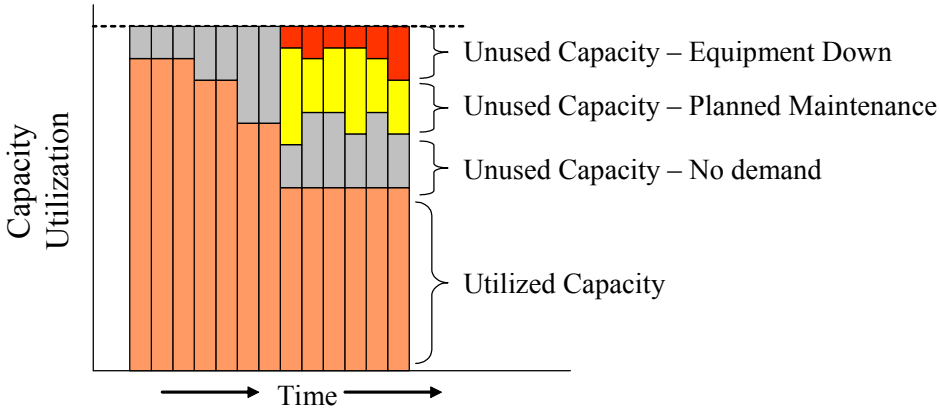



**Figure 10 – Types of unused capacity**

Utilization information includes information about availability, performance, and quality of generated output, so that Overall Equipment Effectiveness (OEE) can be calculated. OEE is a metric indicating the relative productivity of a resource compared to its theoretical performance. While this metric can be determined for all resources used in production, it may be particularly important for bottleneck resources as it identifies areas critical for the improvement of resource productivity.

Example: OEE may be calculated as: (Availability percent) x (Performance percent) x (Quality percent)

Availability percent – The percentage of time the equipment was available for production.

Performance percent – The percent of product produced per time frame (such as part count or total volume) vs the theoretical production rate (best known rate or vendor supplied production speed). – Called Maximum available in this Part.

Quality percent – The percentage of product that is good.

### 6.9.2 Production capability utilization model

Production capability utilization defines the collection of personnel capabilities, equipment capabilities, material capabilities, and process segment capabilities, over a given segment of time. The utilization may be identified as either the maximum available, utilized, or unused capacity. Figure 3 illustrates the model for production capability utilization.

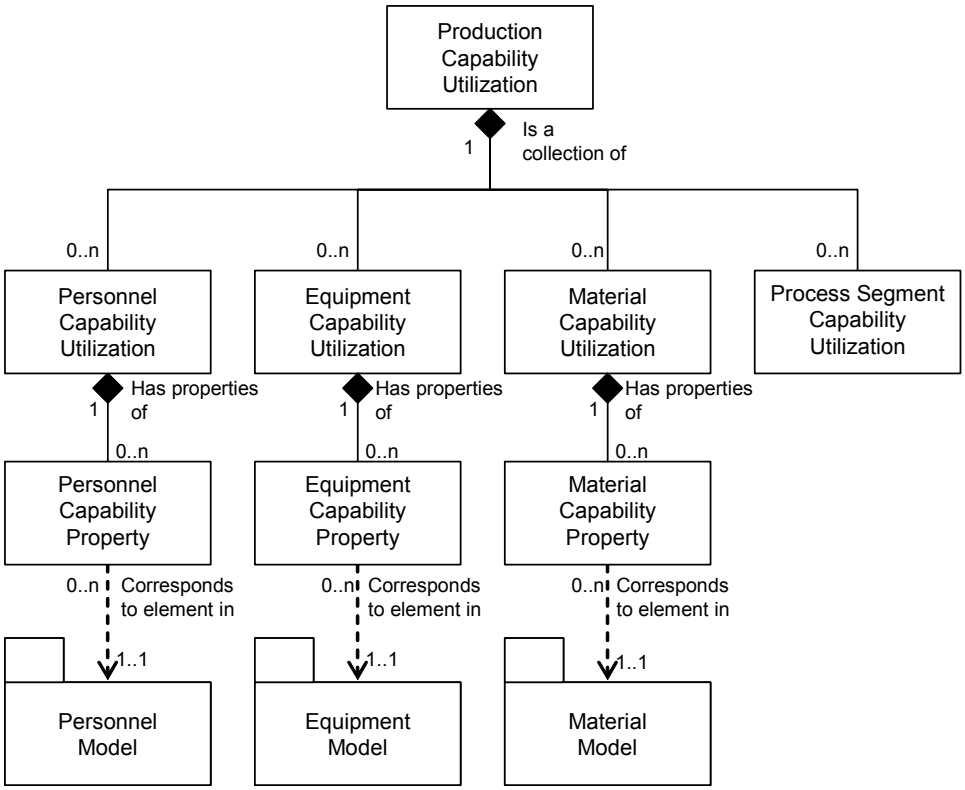



**Figure 11 – Production capability utilization model**

Table 2 lists the attributes of *production capability utilization*.

**Table** 2 — Attributes of production capability utilization

| Attribute Name | Description | Examples |
|---|---|---|
| ID | Gives a unique instance of production capability utilization for a specified element of the equipment hierarchy model [Part 1 Section 5.2] (*enterprise, site, area, process cell, production line, or production unit*). | 2004/12/30-HPC52 |
| | | 2004/12/30-HPC52.01 |
| | | 2004/12/30-HPC52.01.02 |
| Description | Contains additional information and descriptions of the *production capability utilization 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." |
| Utilization Type | The capacity type: Maximum available, Utilized or Unused. | Maximum available |
| | | Utilized |
| | | Unused |
| Reason | Gives the reason for an unused capacity.<br>For example capacity may be unused because of lack of demand for production, or due to planned maintenance of the equipment. | No demand |
| | | Unacceptable quality |
| | | Unplanned Maintenance |
| Reason Info | Provides additional information on the reason for an unused utilization. | "No demand" |
| | | "Color uneven" |
| | | "Pump P101 Failure" |
| Location | An identification of the associated element of the equipment hierarchy model.<br>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 time span defining the capability utilization type. | 2004-12-29 11:59 |
| | | 2004-12-30 11:59 |
| | | 2004-12-31 11:59 |
| End Time | The ending date and time of the time span defining the capability utilization type. | 2004-12-30 12:00 |
| | | 2004-12-31 12:00 |
| | | 2004-01-01 12:00 |

### 6.9.3 Personnel capability utilization

Personnel capability utilization documents the utilization of persons or personnel classes for a specific period of time. The utilization may be identified as maximum available, utilized, or unused. Persons and personnel classes are described in the personnel model in Part 1.

Table 3 lists the attributes of *personnel capability utilization.*

**Table** 3 — Attributes of personnel capability utilization

| Attribute Name | Description | Example |
|---|---|---|
| Personnel Class | Identifies the associated *personnel class* of the capability utilization. | Widget Assembly Machine Operator |
| Person | Identifies the associated *person* of the capability utilization. | SSN 999-55-1212 |
| Description | Contains additional information and descriptions of the *personnel capability utilization* definition. | "Widget machine operator availability over the 2000 New Year boundary" |
| Utilization Type | The capacity type: Maximum available, Utilized, Unused. | Unused |
| Reason | Gives the reason for an unused utilization. | Unavailable operators |
| Reason Info | Provides additional information on the reason for an unused utilization. | "New Year Holiday Party" |
| 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.<br>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 of the time span defining the capacity type.<br>If omitted, then the capacity is associated to the parent *production capability* start time. | 2004-12-30 11:59 |
| End Time | The ending time of the time span defining the capacity type.<br>If omitted, then the capacity is associated to the parent *production capability* end time. | 2005-01-01 12:00 |
| Quantity | Specifies the quantity of the personnel capability. | 48 |
| Quantity Unit of Measure | The unit of measure of the associated quantity. | Hours |

### 6.9.4 Personnel capability property

See Part 2 of this standard for a definition of Personnel capability property.

### 6.9.5 Equipment capability utilization

Equipment capability utilization documents the utilization of equipment or equipment classes for a specific period of time. The utilization may be identified as maximum available, utilized, or unused. Equipment and equipment classes are described in the equipment model in Part 1.

Table 4 lists the attributes of *equipment capability utilization.*

**Table** 4 — Attributes of equipment capability

| Attribute Name | Description | Examples |
|---|---|---|
| Equipment Class | Identifies the associated *equipment class* of the capability utilization. | Widget Jig |
| | | Widget Lathe |
| Equipment | Identifies the associated *equipment* of the capability utilization. | Reactor 101 |
| | | Lathe machine 15 |
| Description | Contains additional information and descriptions of the *equipment capability utilization* definition. | "Widget Jig commitment over the 2000 New Year boundary" |
| | | "Widget Lathe availability over the 2000 New Year boundary" |
| Utilization Type | The capacity type: Maximum available, Utilized, or Unused. | Utilized |
| | | Unused |
| Reason | Gives the reason for an unused utilization. | "Scheduled Maintenance" |
| | | "No demand" |
| Reason Info | Provides additional information on the reason for an unused utilization. | "Planned maintenance shutdown" |
| | | "No Kanban Demand" |
| 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.<br>Zero or more as required to identify the specific scope of the production capability definition. | South Shore Production Plant |
| | | East Wing Production Line #2 |
| Element Type | A definition of the type of associated element of the equipment hierarchy model. | Site |
| | | Production Line |
| Start Time | The starting time of the time span defining the capacity type..<br>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 of the time span defining the capacity type..<br>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. | 48 |
| | | 2 |
| Quantity Unit of Measure | The unit of measure of the associated quantity. | Hours |
| | | Days |

### 6.9.6 Equipment capability property

See Part 2 of this standard for a definition of equipment capability property.

### 6.9.7 Material capability

Material capability utilization documents the utilization of material lots, material sublots, material definitions, or material classes for a specific period of time. The utilization may be

identified as maximum available, utilized, or unused. Material class, material definition, material lot, and material sublot are described in the material model in Part 1.

Table 5 lists the attributes of *material capability utilization.*

**Table** 5 — Attributes of material capability utilization

| Attribute Name | Description | Examples |
|---|---|---|
| Material Class | Identifies the associated *material class* of the capability utilization.* | Polymer sheet stock 1001A |
| | | Lubricant Oil |
| Material Definition | Identifies the associated *material definition* of the capability utilization.* | Sheet stock 1443a |
| | | Lube Oil 8999 |
| Material Lot | Identifies the associated *material lot* of the capability utilization.* | 1443a5mm |
| | | 8999LU-5G |
| Material Sublot | Identifies the associated *material sublot* of the capability utilization.* | 1443a5mm-SL1 |
| | | 8999LU-5G-SL15 |
| Description | Contains additional information and descriptions of the *material capability utilization* definition. | "Polymer sheet stock commitment" |
| | | "Lubricant oil commitment over the 2000 New Year boundary" |
| Utilization Type | The capacity type: Maximum available, Utilized, or Unused. | Maximum available |
| | | Unused |
| Reason | Gives the reason for an unused utilization. | <none> |
| | | "No demand" |
| Reason Info | Provides additional information on the reason for an unused utilization. | <none> |
| | | "No Kanban Signal" |
| 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.<br>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 | Lists the material use: Material Consumed, Material Produced, or Consumable | Material Consumed |
| | | Material Consumed |
| Start Time | The starting time of the time span defining the capacity type..<br>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 of the time span defining the capacity type..<br>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. | 2000 |
| | | 155 |
| Quantity Unit of Measure | The unit of measure of the material quantity. | Sheets |
| | | Liters |

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

### 6.9.8 Material capability property

See Part 2 of this standard for a definition of material capability property.

### 6.9.9 Process segment capability utilization

Process segment capability utilization defines the utilization for one or more resources for a process segment.

A process segment capability is related to a product segment that can occur during production. A process segment capability may relate to one or more products.

Process segment capability identifies:

a) Utilized capacity defines resources that were used in a segment of production of products within acceptable quality limits.

b) Unused capacity defines resource capacity that was not used in a segment of production.

c) Unused capacity may have multiple components, or reasons for the unused capacity, as depicted in Figure 2.

d) The maximum available production capacity utilization is the capability that was available for use in a segment of production.

Process segment capabilities shall be made up of

1. personnel segment capabilities, which lists specific properties required in personnel segment capability properties;
2. equipment segment capabilities, which lists specific properties required in equipment capability properties;
3. material segment capabilities, which lists specific properties required in material segment capability properties.
4. nested process segment capability utilizations, for nested process segments.

Figure 12 illustrates the model for production capability utilization.

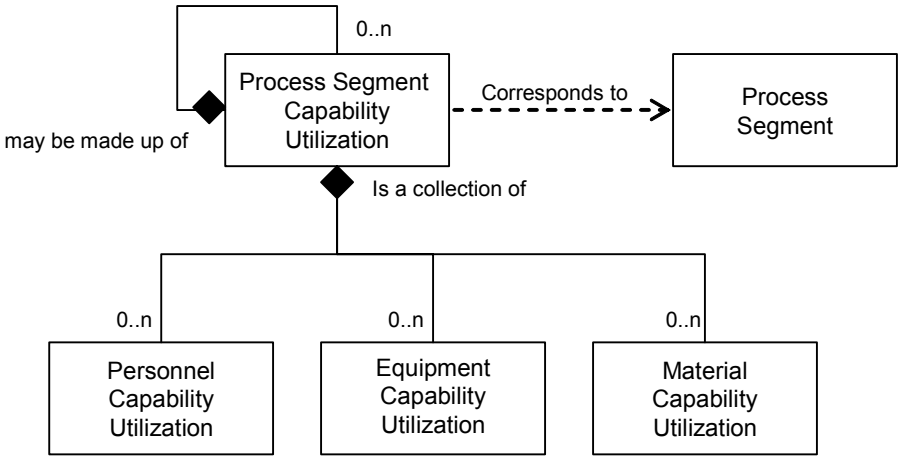


**Figure 12 – Process segment capability model**

Table 6 lists the attributes of *process segment capability utilization. Process segment capability utilization* has an equivalent structure to the personnel, equipment and material structure of *production capability utilization*, except the *process segment capability utilization* is defined for a specific *process segment*.

**Table** 6 — Attributes of process segment capability utilization

| 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 |
| Utilization Type | The capacity type: Maximum available, Utilized, or Unused. | Available |
| Reason | Gives the reason for an unused utilization. | Unavailable operators |
| Reason Info | Provides additional information on the reason for an unused utilization. | "New Year Holiday Party" |
| 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.<br>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 of the time span defining the capacity type.<br>If omitted, then the capability is associated to the parent *production capability* start time. | 1999-12-30 11:59 |
| End Time | The ending time of the time span defining the capacity type.<br>If omitted, then the capability is associated to the parent *production capability* end time. | 2000-01-01 12:00 |

# 7. Production operations management object models

## 7.1 Level 3 production information

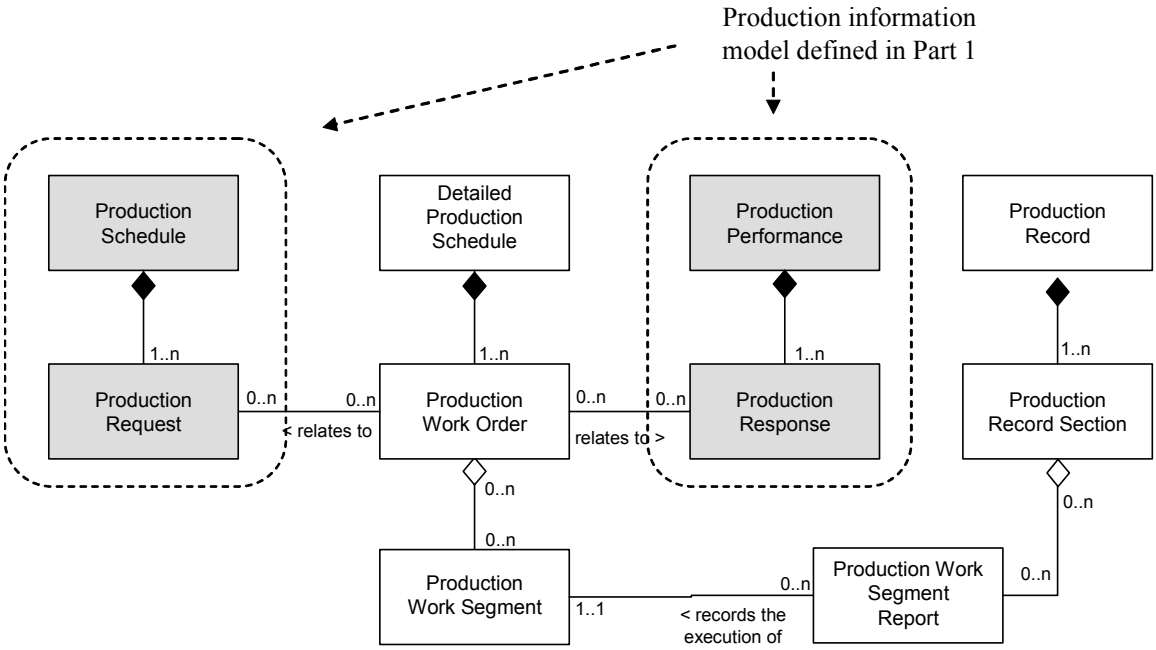
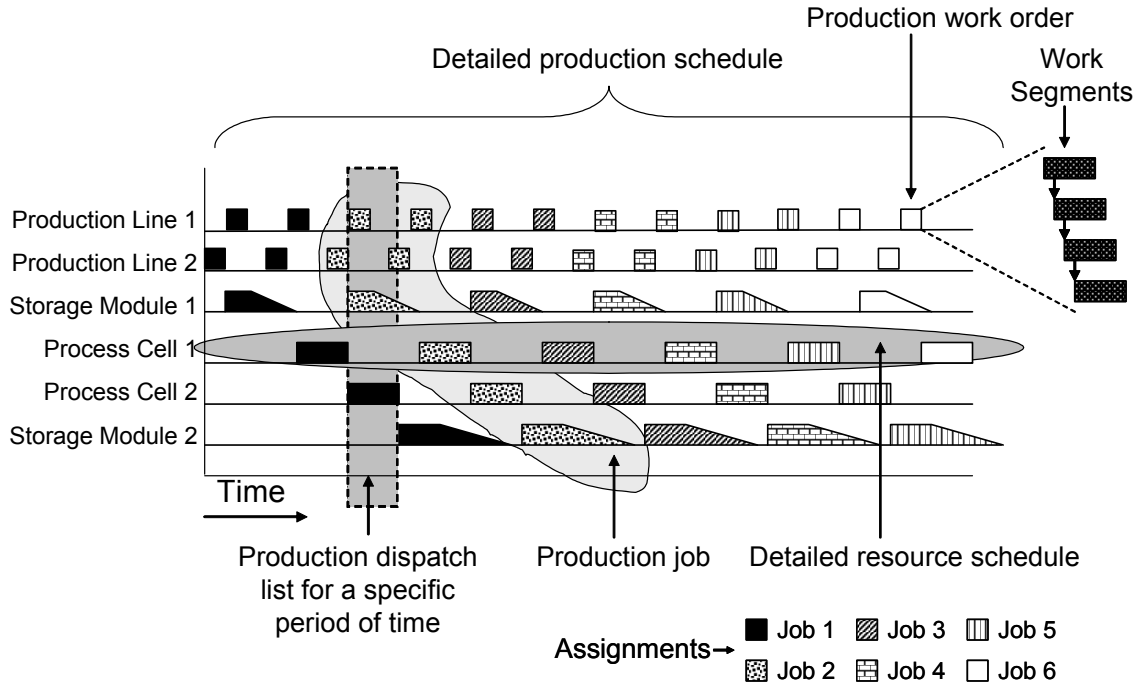



Figure 13 - Production activity objects

## 7.2 Detailed production schedule

### 7.3 Production work order




### 7.4 Production work segment

### 7.5 Production work segment report

### 7.6 Production record

### 7.7 Production record section

## 8. Maintenance operations management object models

## 8.1 Level 3 maintenance information

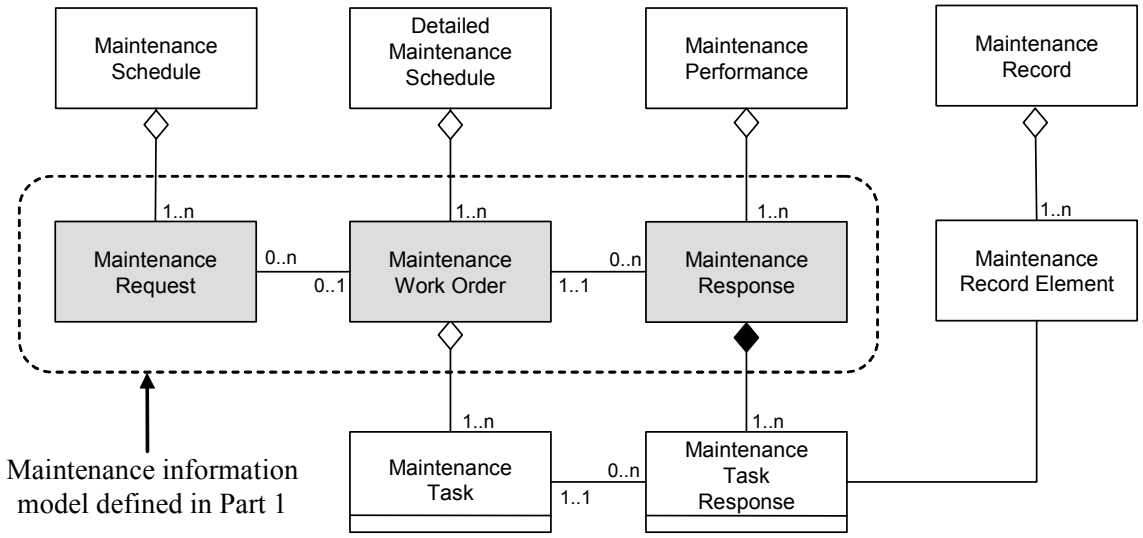
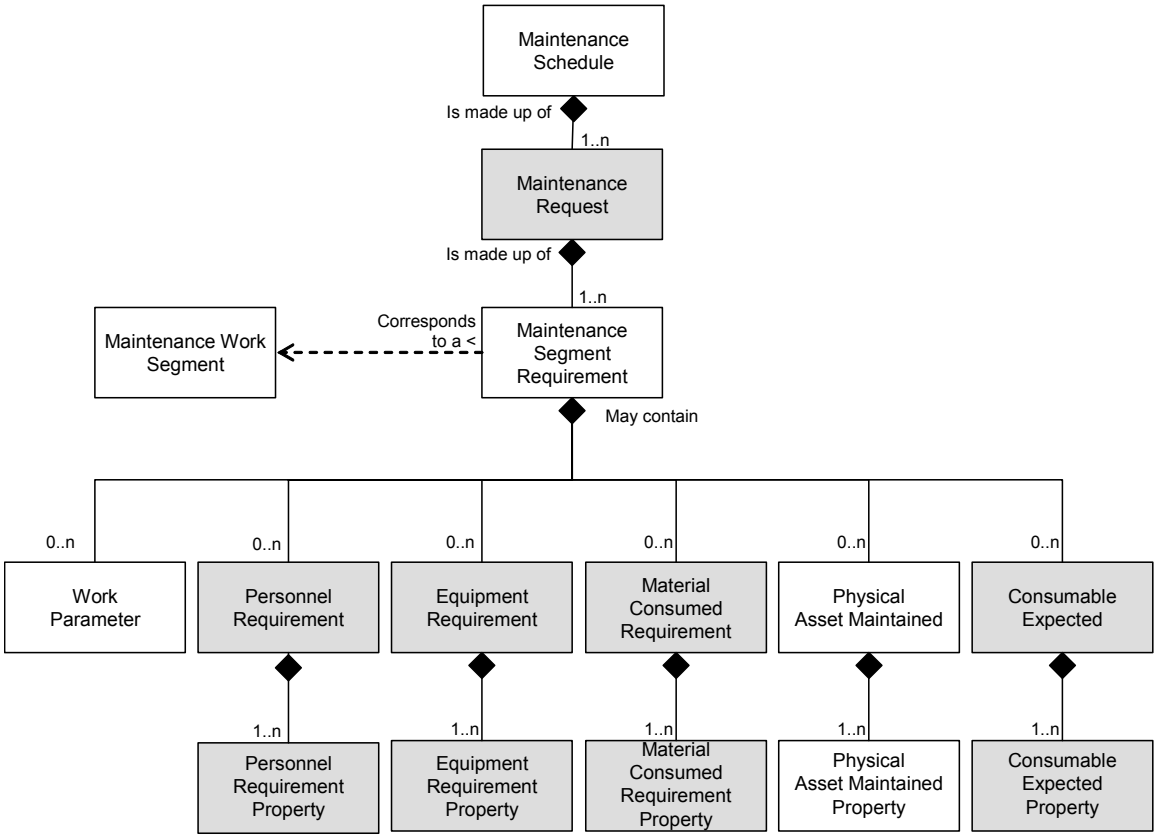


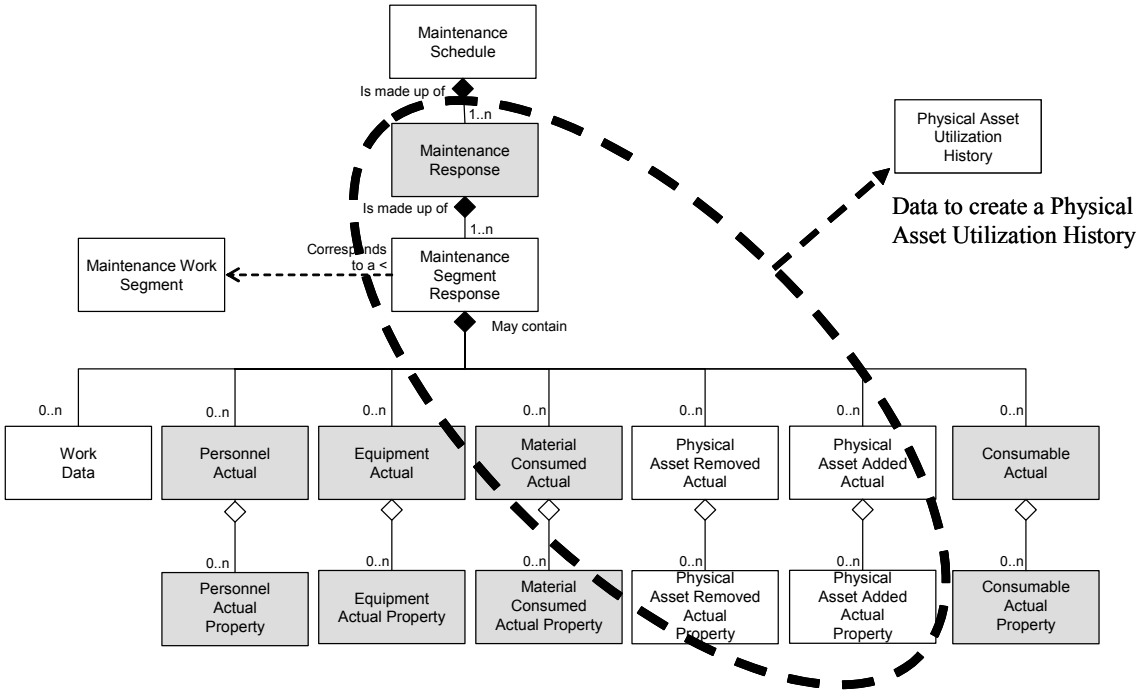

Figure 14 - Maintenance activity objects

## 8.2 Maintenance schedule



## 8.3 Detailed maintenance schedule

## 8.4 Maintenance performance




## 8.5 Maintenance task

## 8.6 Maintenance task response

## 8.7 Maintenance record

## 8.8 Maintenance record section

# 9. Quality operations management object models

## 9.1 Quality test information

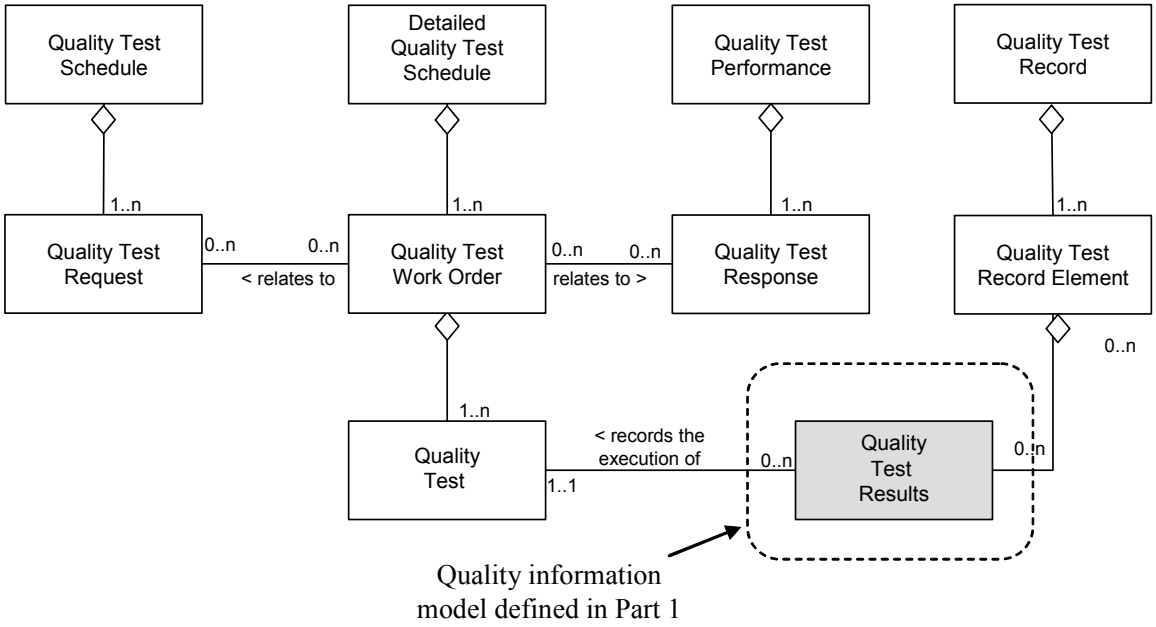
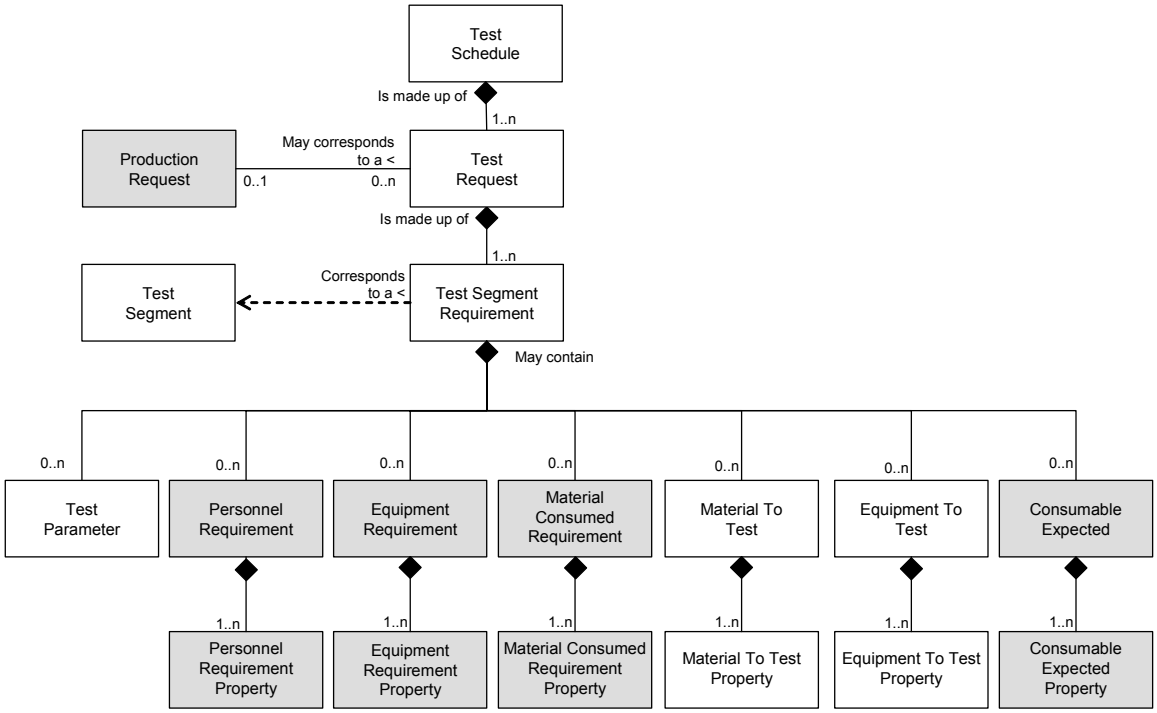



Figure 15 - Quality activity objects

## 9.2 Quality test schedule




## 9.3 Quality test request

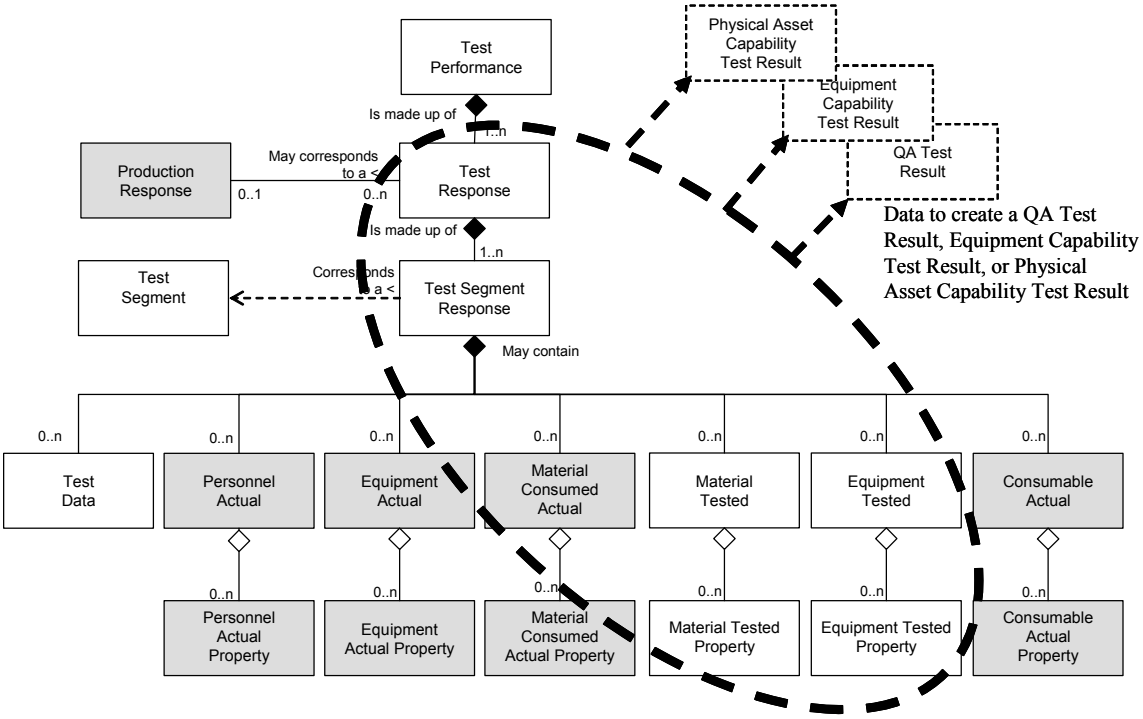
Note: There may be an associated Production Request,

## 9.4 Detailed quality test schedule

## 9.5 Quality test work order

## 9.6 Quality test

## 9.7 Quality test performance




## 9.8 Quality test response

## 9.9 Quality report

## 9.10 Quality test record element

### 9.11 Samples

This will hold the definitions objects representing material which is identified as a sample to be tested. Objects will probably include sample, method, and result objects.

## 10. Inventory operations management object models

### 10.1 Inventory activity information

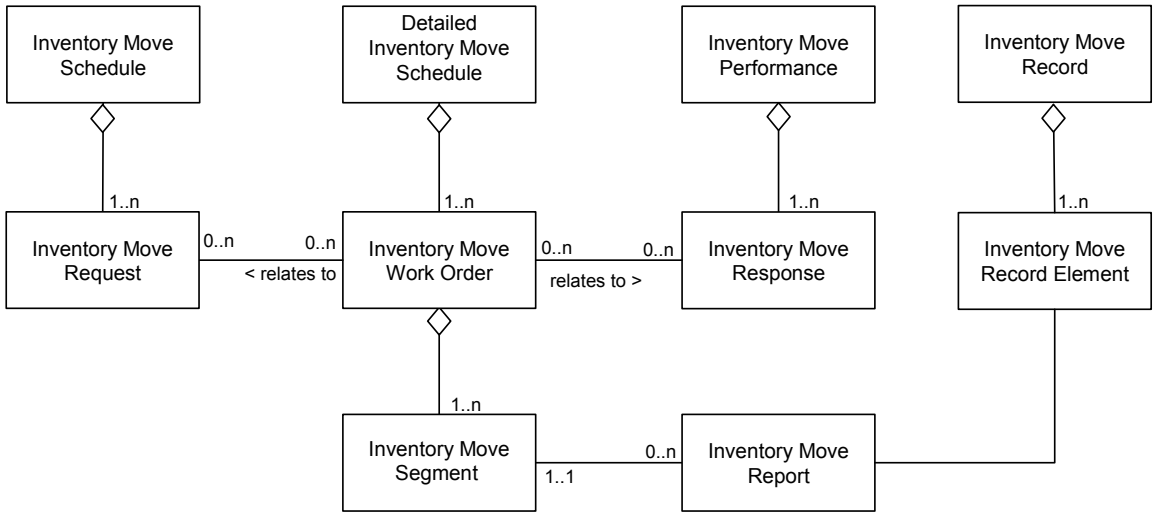



Figure 16 - Inventory activity objects

### 10.2 Inventory move schedule

### 10.3 Inventory move request

### 10.4 Detailed inventory move schedule

### 10.5 Inventory move work order

### 10.6 Inventory move segment

**10.7 Inventory move performance**

**10.8 Inventory move response**

**10.9 Inventory move report**

**10.10 Inventory move record element**

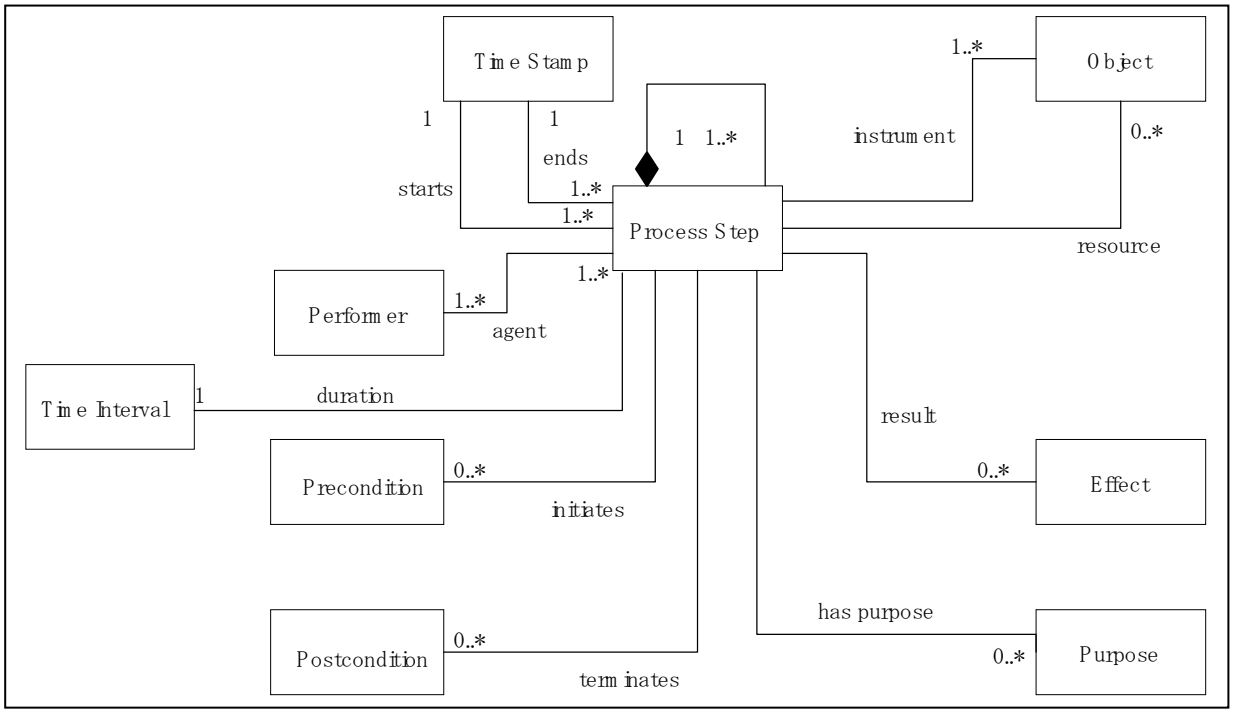
## 11. Completeness and compliance

## Annex A – Questions on the use of the object models

NOTES:

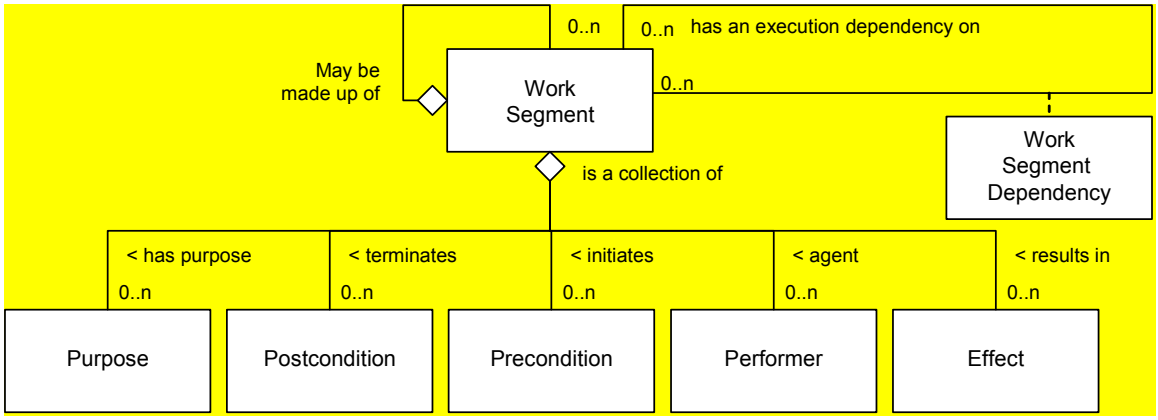
Two views of the Detailed Production Schedule can be identified, namely the *Detailed Production Schedule Procedure* and the *Detailed Production Schedule Record*. The *Detailed Production Schedule Procedure* provides a pattern or script that determines the types of states and events that may occur. A *Detailed Production Schedule Record* is the recorded sequence of states and events that existed during the execution of some *Detailed Production Schedule Procedure*. Each state and event of a Detailed Production Schedule Record may be marked with a time stamp that records its point in time or duration. Both the *Detailed Production Schedule Procedure* and the *Detailed Production Schedule Record* are made up of one or more *Production Steps.*

The concept of *Process Step* is similar to the concept of process or activities defined in other standards (e.g. DAML-S, PSL). *Process Step* is the class of things that happen and have temporal parts or stages that are necessary in order to satisfy the objectives of a manufacturing business. A *Process Step* can be composed of other *Process Steps*. Furthermore, Process Steps can be used not only in batch processes but also in continuous processes. For example, accurate representations of startup and shutdown operating procedures can be described so as to comply with safety standards such as OSHA 1910.119. The data structure of *Process Step* is shown below.




The duration of a *Process Step* is the time interval during which the *Process Step* evolves.

Editor's Note: I have reformatted the above to be consistent with the other diagrams. The starts, ends, and time interval would either be attributes or be elements of the task report. The "Objects" could be the personnel, equipment, and material defined in Figure 6.




Time stamps are extensionless points on the universal timeline. Time stamps describe when the *Process Step* starts and ends. For example, the starting time of a *Process Step* in a Gantt chart that that has a value of 14:00hrs.

*Object* is a concrete or abstract thing that can participate in an activity. Examples of objects are plant operators, plant equipment, or material.

The *resource* of a *Process Step* refers to *Objects* that are present at the beginning of the *Process Step* and are changed by the *Process Step* . For example, vinyl chloride is a *Resource* in the *Process Step* of producing PVC.

The *instrument* of a *Process Step* describes the role of *Objects* that are used by a *Performer* in bringing about the *Process Step* in a way that that *Object* is not changed by the *Process Step* . For example, 'Reactor-101' is a Tool of 'React'.

The *Effect* of a *Process Step* is the result of performing the *Process Step* . For example, the *Effect* of a *Process Step* that is used to open a valve would be 'Valve Open'.

The *Performer* of a *Process Step* refers to the active determinant, either human, software, machine. Examples are instances of plant operators, control systems, MES systems.

*Purpose* describes the goals of a *Process Step*. In other words, *Purpose* refers to an expected and desired outcome as well as the rationale that explains the decision of carrying out the *Process Step* including the engineer's intention.

Another concept that will complement the specification is *precondition*. A precondition of a *Process Step* is specified to indicate that the *Process Step* can either start only if the precondition is true. For example the precondition 'PIC-06 > 75 Kgf/cm$^2$G and TY-28 > 175$^o$C' of a *Process Step* that has the *Effect* 'Valve-101 Open' determines that valve Valve-101 should open if the specified pressure and temperature state is attained.

Analogously, the *Postcondition* of a *Process Step* indicates that the *Process Step* can finish only if the postcondition is true.

**Related efforts**

Other colleagues are working on similar ideas, including those working on the following projects:

1. Process Specification Language http://ats.nist.gov/psl/
2. IEEE SUO Working Group http://suo.ieee.org/.
3. Core Plan Representation Project, http://projects.teknowledge.com/CPR2/
4. The Share Planning and Activity Representation Project,

   http://www.aiai.ed.ac.uk/project/spar/
5. DAML-S, http://www.daml.org/services/

**NOTES:**

**Procedures, Segments, and Basic Resource Capabilities**

This write-up defines some of the thoughts on handling manufacturing procedures and how those relate to actual production and the process/product segments on the ISA 95 standard.

One way to look at this is that there is a physical production process that occurs to make a product. This can be drawn using the IEDF type diagram, which indicates the flow of materials and the flow of control. See Figure 17. While this picture only shows the physical elements of production, there may be other elements of production dealing with personnel, material, or information transfers. these basic elements could be the equivalent of equipment-phases in the S88 model. (Note: While this example shows the physical production for a single product, the assumption is that the same elements could be reused for other products.)

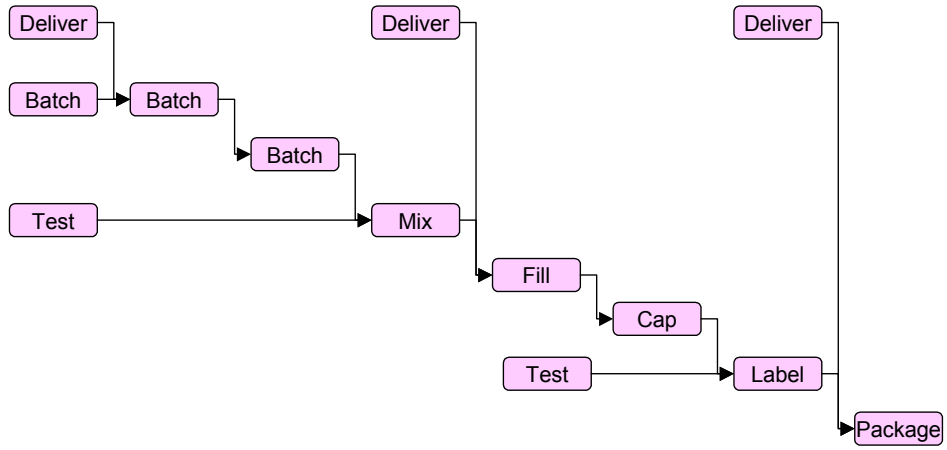



Figure 17 - Typical production elements to make a product

This set of production steps could be viewed by the business as a set of segments. See Figure 18 Let us assume that there are three places where intermediate material most be inventoried and/or the activities must be costed. These would be modeled in using the ISA95 as three different product segments (since this is related to a specific product). In this example the material delivery elements are costed with the segment where they are used. There is also a single product segment that contains the three subsegments.

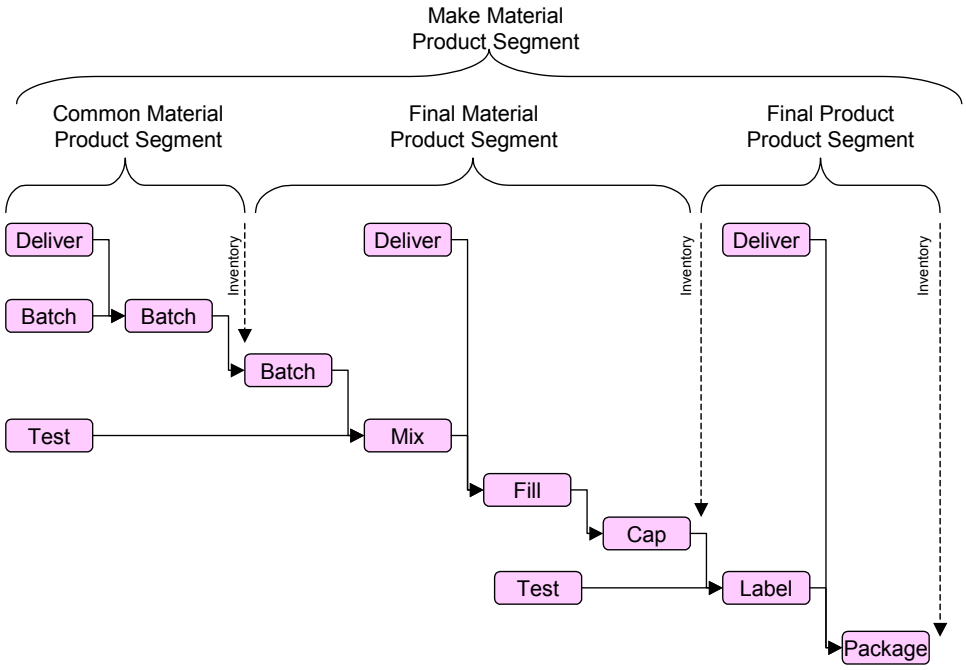



Figure 18 - Product segment mapping to production elements

The same elements of production are coordinated and managed using a set of manufacturing procedures. See Figure 19. Following the ISA 95 Part 3 models, there could be three different

types of procedures, QA test procedures, production procedures, and inventory material movement procedures.

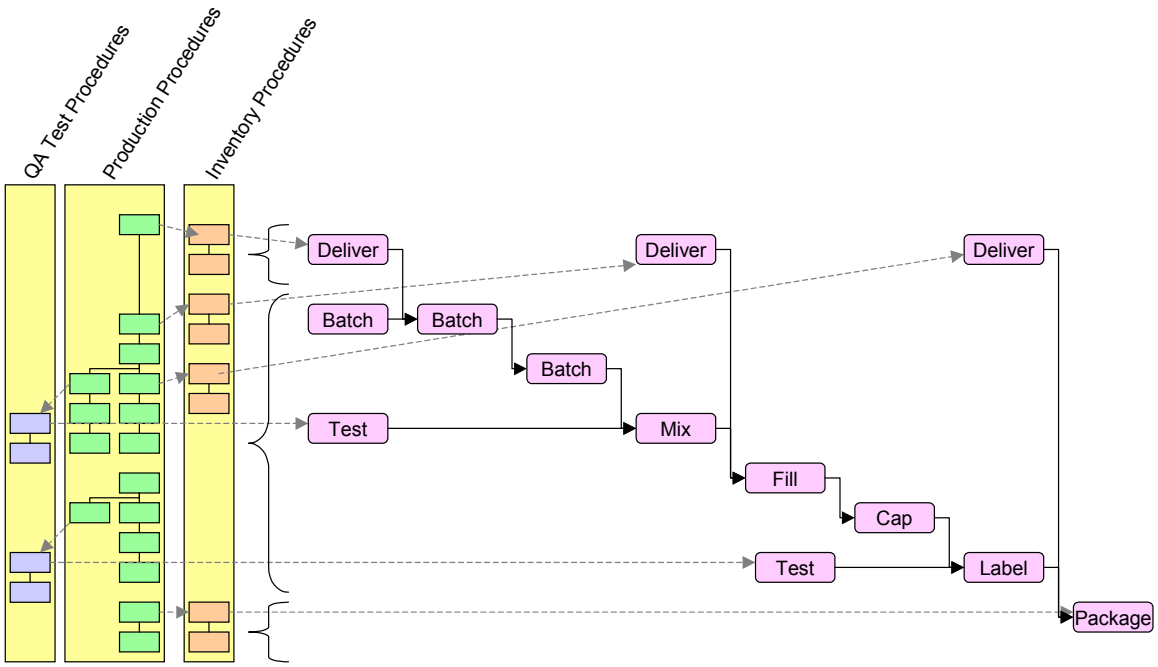



Figure 19 - Manufacturing procedure mapping to production elements

The production procedures could be represented using BPML, which define a standard way to represent procedures. There may be multiple procedures, with come form of coordination control through a paper process or an MES system. Figure 20 shows the two (basically) orthogonal views of the basic production elements into product segments and manufacturing procedures.

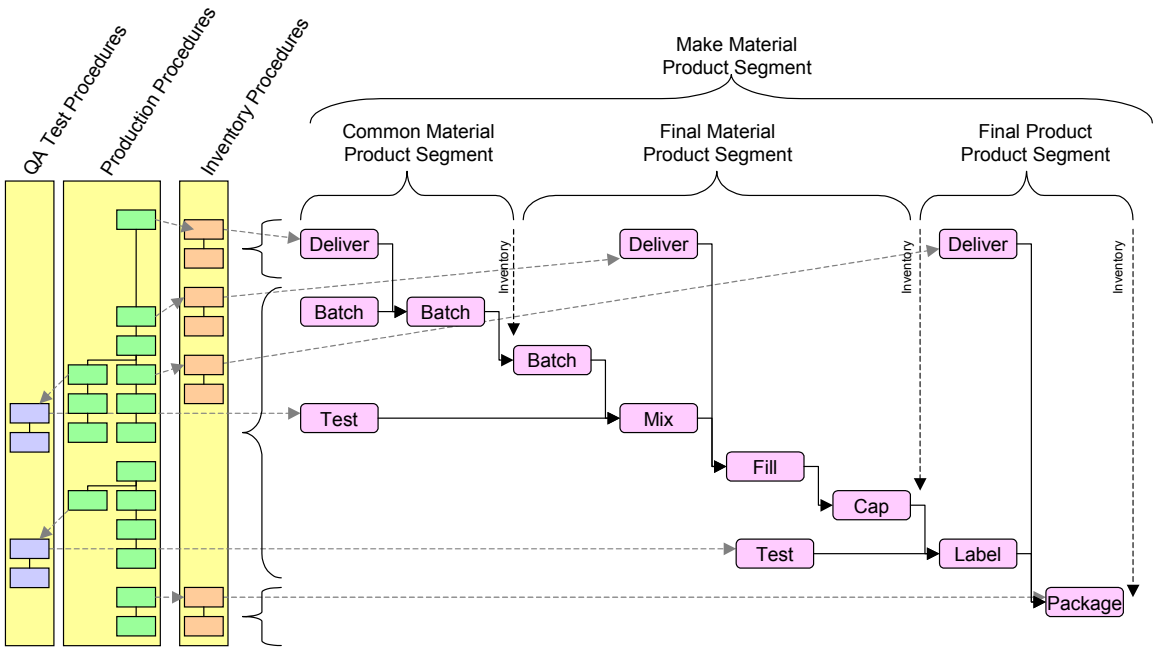



Figure 20 - Orthogonal mapping of operations and business views

So the question is, what do we name the little pink boxes, the production elements used by the manufacturing procedures, and also see by the product segments.