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**Enterprise-Control System Integration –
Part 4: Objects and attributes for manufacturing
operations management integration**

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Enterprise-Control System Integration – Part 4: Objects and attributes for manufacturing operations management integration

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 4: Object model attributes for manufacturing operations management integration

FOREWORD

This is Part 4 of a series of standards that defines the interfaces between enterprise activities and control activities.

The scope of this Part 4 standard is limited to defining the details of the interface content within manufacturing operations management. The scope of this Part 4 standard is limited to the definition of object models and attributes for the information defined in Part 3. The goal is to reduce the effort, cost, and errors associated with implementing these interfaces.

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

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

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INTRODUCTION

This Part 4 standard further defines the object models and attributes involved in data exchange between the categories and activities defined in ANSI/ISA-95.00.03-2005, Enterprise-Control System Integration - Part 3: Activity Models of Manufacturing Operations Management (hereafter referred to as Part 3). The models and terminology defined in Part 3 and Part 4

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

Specifically, the Part 3 and Part 4 standards provide a standard terminology and a consistent set of concepts and models for integrating manufacturing operations management 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 manufacturing operations management 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 3 and Part 4 standards may be used to reduce the effort associated with implementing new product offerings. The goal is to have manufacturing operations management 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 manufacturing operations management systems;
- b) force users to abandon their current way of handling integration; or
- c) restrict development in the area of integration of manufacturing operations management systems.

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 4: Object and attributes for manufacturing operations management integration

1 Scope

This ISA-95 Part 4 standard, in conjunction with ANSI/ISA-95.00.03-2005, Enterprise-Control System Integration—Part 3: Activity Models of Manufacturing Operations Management, specifies interface content between manufacturing operations management categories and activities. The interfaces considered are the interfaces across and within Level 3 categories of the functional hierarchical model defined in the ISA-95 Part 1 standard (see Clause 2 below). The goal is to reduce the risk, cost, and errors associated with implementing these interfaces.

The scope of Part 4 is limited to the definition of object models and attributes exchanged between activities defined in Part 3. Interfaces within Level 2, and Level 3 to Level 2, are out of scope. Interfaces with Level 4 are defined in the ISA-95 Part 2 standard.

2 Normative references

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

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

ANSI/ISA-95.00.02-2010 (IEC 62264-2 Mod) - Enterprise-Control System Integration - Part 2: Object Model Attributes

ANSI/ISA-95.00.03-2005, Enterprise-Control System Integration Part 3: Activity Models of Manufacturing Operations Management

ANSI/ISA-88.00.01-2010, Batch Control – Part 1: Models and Terminology

IEC 62264-1, Enterprise-control system integration – Part 1: Models and terminology

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

ANSI/ISA-18.2-2009, Management of Alarm Systems for the Process Industries

ISO/IEC 19501:2005, Information technology-- Open distributed processing -- Unified modeling language (UML) Version 1.4.2

ISO/IEC 19505-1, Information technology -- OMG Unified modeling language (OMG UML) Version 2.1.2 -- Part 1: Infrastructure

ISO/IEC 19505-2, Information technology -- OMG Unified modeling language (OMG UML) Version 2.1.2 -- Part 2: Superstructure

ISO/CD 22400-1 - Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management — Part 1: Overview, concepts and terminology

ISO/DIS 22400-2 Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management — Part 2: Definitions and descriptions

3 Terms and definitions

For the purpose of this Part 4 standard the definitions given in IEC 62264-1 and the following apply.

3.1 Definitions

3.1.1

job list

collection of job orders for one or more work centers and/or resources for a specific time frame

3.1.2

job order

smallest unit of work for execution as defined by a work master

3.1.3

job response

data on the execution of a job order pertaining to production, maintenance, inventory or quality activities, or any combination of the activities

3.1.4

resource relationship network

one or more expressions of a relationship between two or more resources

3.1.5

work alert

notification of a Level 3 event that does not require acknowledgement

3.1.6

work capability

particular combination of resources with certain capabilities that are necessary and sufficient to accomplish one or more steps of a work definition

3.1.7

work definition

collection of information about resources and workflow definitions associated with work

3.1.8

work directive

work definition derived from a work master and used to perform a job order

3.1.9

work KPI

quantifiable measurement that has a business or operational value regarding performance of work

3.1.10

work master

type of work definition that is a template for work to be performed for a job order

3.1.11

work performance

collection of work responses

3.1.12

work master capability

ability of resources to perform work and the capacity of those resources

3.1.13

work request

collection of job orders

3.1.14

work response

collection of job responses

3.1.15

work schedule

collection of work requests

3.1.16

workflow

- model to represent work as a pattern of activities
- information used to orchestrate the execution of procedures

EXAMPLE a repeatable sequence of procedures, enabled by an organization of resources with defined roles corresponding to flows of mass, energy or information

3.1.17

workflow process

the procedure part of a work definition describing a workflow

3.2 Abbreviations

BPMN	Business Process Modeling Notation
KPI	Key Performance Indicator
MOM	Manufacturing Operations Management
SOP	Standard Operating Procedures
UML	Unified Modeling Language
UTC	Coordinated Universal Time

4 Information exchange between manufacturing operations

4.1 Activity information exchange network

A set of models are used to represent the information exchanged between activities of manufacturing operations management categories, as defined in Part 3. This is illustrated in Figure 1 with each information exchange model represented as black rounded rectangles. This Part defines information which can be exchanged between Level 3 activities (represented as ellipses in the figure) within an operational category or across operational categories. Part 2 defines objects that may be exchanged between Level 4 activities and Level 3 activities and are represented as yellow rounded rectangles. Other information (represented as hashed elements) shown in Figure 1 are defined in other standards, such as the ANSI/ISA-88.00.01-2010, IEC 61512 and the IEC 62541 standards.

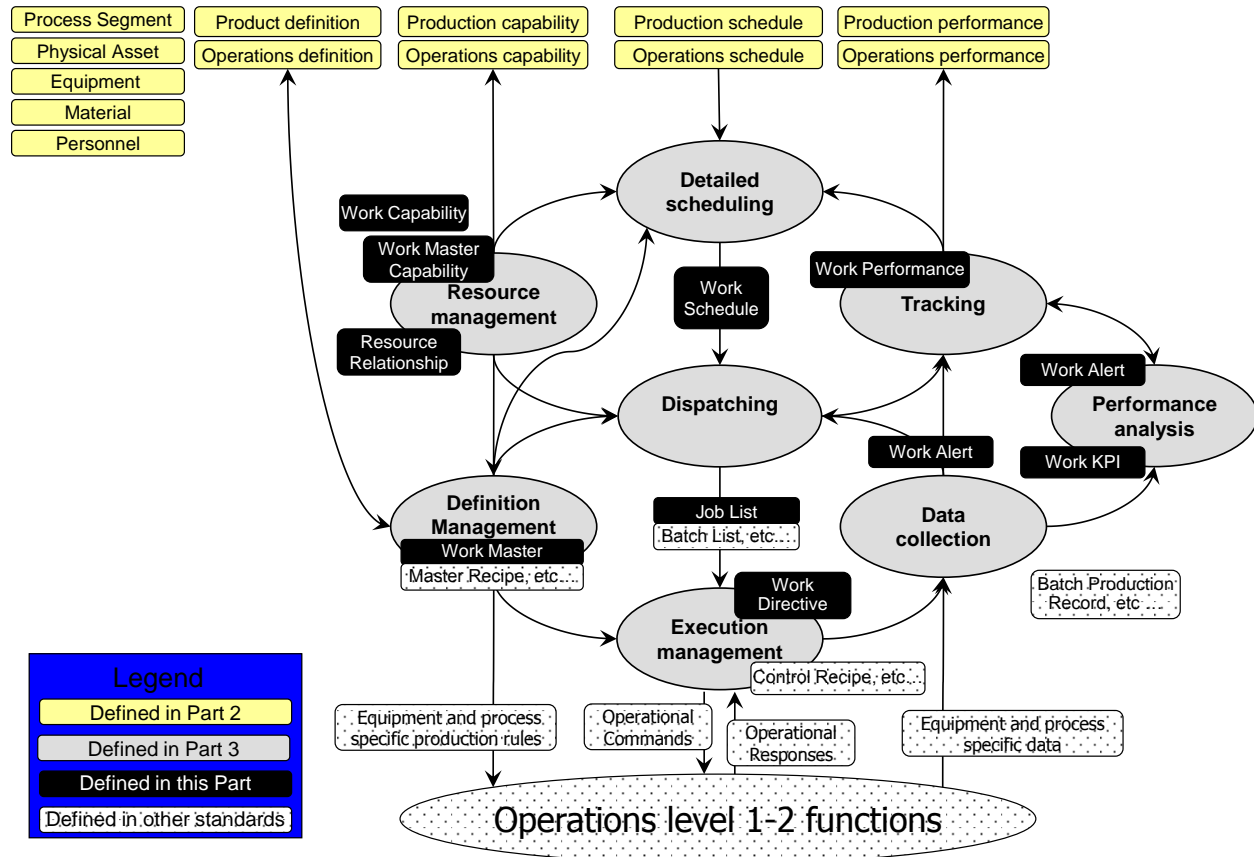


Figure 1 — Information exchange models for manufacturing operations management

NOTE The ISA-88 and IEC 61512 standards define object models that relate to the lower elements of the Level 3 activities and define the information used to create and manage master recipes, control recipes, batch lists, and batch production records. Equivalent structures, or the IEC 61512 structures, could be used for other types of production. This standard does not redefine these objects.

4.2 Information exchange models

4.2.1 Level 3 object models

The information exchange models define structures that can be used to define, manage, and execute work within Level 3. The work models define the managed elements of work. The models are similar in structure to those defined in Part 2 but are defined for Level 3 information exchange.

4.2.2 Process segments and work masters

The Part 2 models define the view of manufacturing as seen by Level 4 business systems and based on a view of the manufacturing processes defined in *Process Segments*. This Part's models define the view of manufacturing as seen by Level 3 operations and are based on a view of the manufacturing processes defined in *Work Masters and Work Directives*.

Work masters and work directives are the elements of manufacturing activities that are visible to manufacturing operations management processes. They define the resources and steps for job orders that are scheduled, displayed, executed, and tracked by Level 3 activities.

NOTE: Part 2 models are used to exchange information from the process segment (business) view for Level 4 planning. Models such as operations definition and operations schedule support the allocation of resources and scheduling activities to the plant. Part 4 models are used to exchange information for Level 3 execution. Models such as work definition reference the operations definition exchanged with

Level 4, but they have the details needed for actual execution of Level 3 activities. See Annex C for additional discussion of Part 2, Part 4, and ISA-88 / IEC 61512 model relationships.

4.2.3 Common resource definitions

The object models in this Part use the personnel, equipment, physical asset, and material information defined in Part 2 of this standard. When used with Level 3 work objects, the personnel, equipment, physical asset, and material information may include information required for Level 3 activities in addition to the information required to be shared with Level 4 activities.

EXAMPLE 1 The personnel information required for Level 3 activities may include detailed experience and qualification levels that are not shared with a Level 4 personnel or training management system.

EXAMPLE 2 The material information maintained for Level 3 activities may include subplot information which is not shared with Level 4 material management systems.

EXAMPLE 3 Delivery, usage and emission of energy units may be handled as material information.

4.2.4 Level 3 work models

The following object models are defined in this Part.

1. Resource Relationship Network – Resource relationship networks are created by tasks in resource management and definition management activities.
2. Work Definition
 - a. Work Master – Work masters are created by an engineering activity defined in Part 1 and to be managed by a task in definition management activities.
 - b. Work Directive – Work directives are created by a task in execution management activities.
3. Work Schedule – Work schedules are created by a task in detailed scheduling activities.
4. Job List – Job lists are created by a task in dispatching activities.

NOTE In this part of the standard, the term job is sometimes used instead of job order when referring to an entry in a job list.
5. Work Performance – Work performances are created by a task in tracking activities.
6. Work Capability – Work capabilities are created by a task in resource management activities.
7. Work Master Capability – Work master capabilities are created by a task in resource management activities.
8. Work KPI – Work KPIs are created by a task in analysis activities.
9. Work Alert – Work alerts are created by any activity in the activity model.

4.2.5 Value types

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

Value attributes are also used to exchange the allowed or expected values in properties and parameters. See Part 2 Clause 4.8 Value types for a complete definition.

5 Object model attributes

5.1 Introduction

This clause describes the object models and attributes for information exchanged in between Level 3 activities. The attributes are part of the definition of object models for exchanged information.

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

5.2 Attribute extensibility

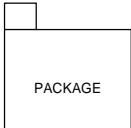
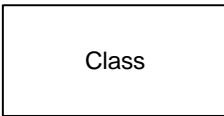

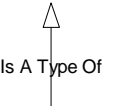
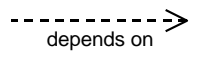
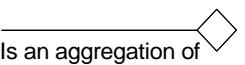
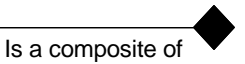
For particular applications the objects defined in the object models will be extended through the addition of attributes to object class definitions. Accordingly this standard provides for attributes that are application or industry specific, to be modeled in terms of properties and represented in property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

5.3 Object model structure

The object models are depicted using the Unified Modeling Language (UML) notational methodology, as defined in ISO/IEC 19501, 19505-1 and 19505-2.

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

Table 1 — UML notation used

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

5.4 Conventions used in tables

5.4.1 Table entries

Each table includes a listing of object attributes, as follows, the object identification, data types, and examples of the attributes and its values.

5.4.2 Object identification

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

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

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

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

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

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

5.4.3 Data types

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

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

EXAMPLE 2 A date/time value may be represented in ISO 8601 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.

5.4.4 Presentation of examples

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

Table 2 — Example table

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Name of first attribute	Description of first attribute	Production example	Maintenance example	Quality example	Inventory example
Name of second attribute	Description of second attribute	Production example	Maintenance example	Quality example	Inventory example
Name of third attribute	Description of third attribute	Production example	Maintenance example	Quality example	Inventory example

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

The examples are purely made up. 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.

5.4.5 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 2 object model figures. See Part 2 Clause 4.5.5 Data relationships, for a complete description of data relationships.

6 Resource relationship network model

6.1 Resource relationship network

Resource relationship networks shall be used to describe relationships between two or more resources in order to represent information that may be required for detailed scheduling activities, dispatching activities, execution activities, or other Level 3 activities.

Each resource relationship network is a collection of relationships.

Each relationship shall be represented as a directed connection between a “To Resource” and a “From Resource”..

NOTE 1 Relationships are represented as directed multi-graphs in graph theory. Each relationship represents an “edge” with the resource references represented as vertices.

NOTE 2 The attributes of the resource relationship elements are used to represent constraints in the network, such as constraints in flow, direction, set or ordering.

EXAMPLE 1 A “route” resource network connection between equipment may include properties that include the material transport time between the equipment and the material transfer rate between the equipment.

EXAMPLE 2 An “approved for use” resource network connection between equipment and material definitions may define which specific equipment has been approved for use with specific materials. A property of the resource network connection may be the date at which the approval for use is expired or revoked.

EXAMPLE 3 A “material substitution” resource network connection may define a primary material and the list of possible alternate materials.

Each resource network connection is defined by a resource network connection type. The resource network connection type may include property definitions, which define the allowable resource network connection properties.

NOTE 3 The resource relationship network model is conceptually similar to the MIMOSA CCOM network model. See Annex A Bibliography

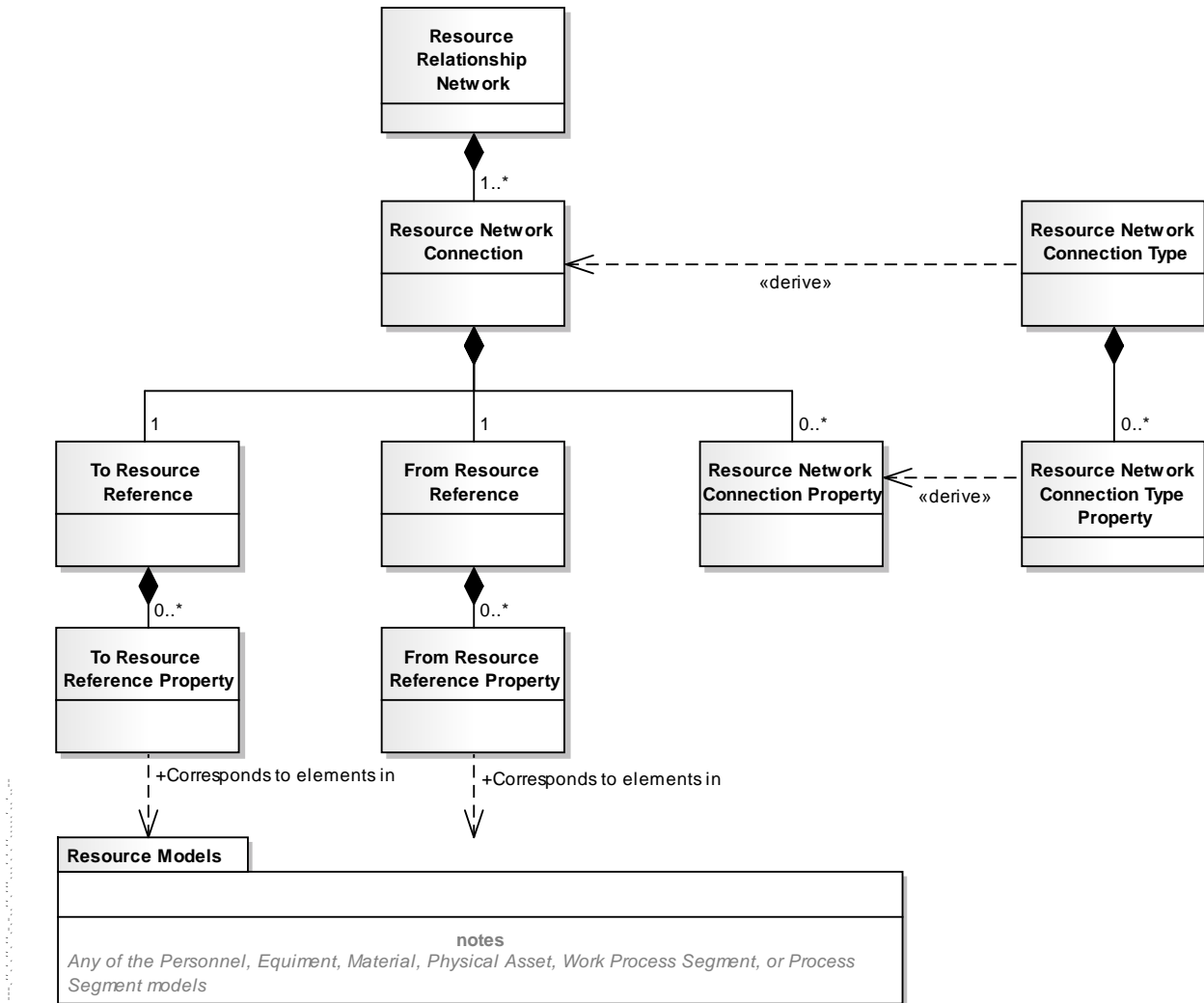


Figure 2 — Resource relationship network model

6.2 Resource relationship network attributes

A *resource relationship network* shall be a composition of one or more *resource network connections*.

Table 3 defines the attributes for *resource relationship network* objects.

Table 3 — Resource relationship network attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>resource relationship network</i> .	BN5FP	B5EN	B5RS	BFFTR
Description	A description of the <i>resource relationship network</i> .	Building 5 flow path	Building 5 electrical network	Building 5 receive signoff	Building 5 fork truck route
Relationship type	Optional: Defines the type of the relationship. The defined types are: Physical – The elements of the relationship are physically connected or in the same area. Logical – The elements of the relationship are not necessarily physically connected or in the same area.	Physical	Physical	Logical	Logical
Relationship form	Optional: Defines the form of the relationships. The defined types are: Permanent – The relationship is not intended to be split or changed during operations processes. Transient – The relationship may be split or changed during operations processes.	Permanent	Permanent	Permanent	Transient

6.3 Resource network connection

The directed relationship between two resources in a resource relationship network shall be defined as a *resource network connection*.

A *resource network connection* shall be composed of the following:

- a “From” relationship defining one *resource reference* (as the starting point of a directed connection or the tail of an arrow that graphically represents the relationship)
- a “To” relationship defining one *resource reference* (as the ending point of a directed connection or the head of an arrow that graphically represents the relationship)
- zero or more *resource network connection properties*
- an associated *resource network connection type*.

Table 4 defines the attributes for *resource network connection* objects.

Table 4 — Resource network connection attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>resource network connection</i> .	7685	6383290	Hyuwq9	TT28623
Description	A description of a resource network connection.	Piping	Wiring	Next signer	Next stop

6.4 Resource network connection property

A property of a resource network connection shall be defined as a *resource network connection property*.

Resource network connection properties are used to contain property values that are associated with the specific connection.

Table 5 defines the attributes of *resource network connection property* objects.

Table 5 — Resource network connection property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>resource network connection property</i> .	Pipe type	Gauge	N/A	Inside
Description	Additional information about the <i>resource network connection property</i> .	Type of piping	Wire type	N/A	Location
Value	The value, set of values, or range of the property.	53	20	N/A	TRUE
Value unit of measure	The unit of measure of the associated property value, if applicable.	Steel grade	AWG	N/A	Boolean

6.5 From resource reference

A “from” reference to a resource shall be defined as a *from resource reference*.

A *from resource reference* may be composed of zero or more *from resource reference properties*.

Table 6 defines the attributes for *from resource reference* objects.

Table 6 — From resource reference attributes

Attribute Name	Description	Production Examples	Maintenance Examples	Quality Examples	Inventory Examples
ID	A unique identification of a <i>from resource reference</i> .	12345	12346	A123	S7728
Resource ID	The ID of a resource.	B5Tank08	B5V480Box	Supervisor	Line3EndOf Line
Resource type	The type of the resource. The defined types are: Personnel class Person Equipment class Equipment Physical asset class Physical asset Material class Material definition Material lot Material subplot Work master Process segment	Equipment	Physical asset	Personnel class	Equipment

6.6 From resource reference property

A property of a *from resource reference* shall be defined as a *from resource reference property*.

NOTE A *from resource reference* with one or more *from resource reference properties* define the subset of the *resource* that has the defined *resource property* values.

Table 7 defines the attributes for *from resource reference property* objects.

Table 7 — From resource reference property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>from resource reference property</i> .	A7872	CB101	Hhjjw78	N/A
Property ID	The ID of a resource property.	Outlet flow rate	Circuit breaker	Shift	N/A
Property value	A value of a property that is used to identify the subset of the resources that are referenced.	200 L/Min	40 AMP	First	N/A
Value unit of measure	The unit of measure of the associated property value, if applicable.	Steel grade	Type	N/A	Boolean

6.7 To resource reference

A “to” reference to a resource shall be defined as a *to resource reference*.

A *to resource reference* may be composed of zero or more *to resource reference properties*.

Table 8 defines the attributes for *to resource reference* objects.

Table 8 — To resource reference attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>to resource reference</i> .	12345	12346	A123	S7728
Resource ID	The ID of a resource.	B5Tank08	B5V480Box	Supervisor	Line3EndOf Line
Resource type	The type of the resource. The defined types are: Personnel class Person Equipment class Equipment Physical asset class Physical asset Material class Material definition Material lot Material subplot Work master Process segment	Equipment	Physical asset	Personnel class	Equipment

6.8 To resource reference property

A property of a *to resource reference* shall be defined as a *to resource reference property*.

NOTE A *to resource reference* with one or more *to resource reference properties* define the subset of the *resource* that has the defined *resource property* values.

Table 9 defines the attributes for *to resource reference property* objects.

Table 9 — To resource reference property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>to resource reference property</i> .	A7872	CB101	HhJw78	N/A
Property ID	The ID of a resource property.	Outlet flow rate	Circuit breaker	Shift	N/A
Property value	A value of a property that is used to identify the subset of the resources that are referenced.	200 L/Min	40 AMP	First	N/A
Value unit of measure	The unit of measure of the associated property value, if applicable.	Steel grade	Type	N/A	Boolean

6.9 Resource network connection type

A definition of a type of a resource network connection shall be defined as a *resource network connection type*.

A *resource network connection type* may be composed of zero or more *resource network connection type properties*.

Table 10 defines the attributes of *resource network connection type* objects.

Table 10 — Resource network connection type attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>resource network connection type</i> .	PC01	ME1	QE1	IE1
Description	A description of a resource network connection type.	Distribution piping	40A breakers	N/A	WIP replenishment stops
Type	The connection type	Piping connection	Electrical connection	N/A	WIP-STOPPS

6.10 Resource network connection type property

A property of a resource network connection type shall be defined as a network connection type property.

Resource network connection type properties may be used to specify the defined properties that can be associated with the specific network connection type.

Table 11 defines the attributes of *resource network connection type property* objects.

Table 11 — Resource network connection type property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of a <i>resource network connection type property</i> .	Pipe type	LowArc	N/A	Inside
Description	Additional information about the <i>resource network connection type property</i> .	Type of piping	Breaker low arc	N/A	Location
Value	The default value, set of values, or range of the property.	53	1	N/A	TRUE
Value unit of measure	The unit of measure of the associated property value, if applicable.	Steel grade	Type	N/A	Boolean

7 Work definition model

7.1 Work definition

An identification of the resources and workflow definition required to perform a specified unit of work shall be defined as a work definition. The work definition may apply to the defining of production, maintenance, quality test and inventory activities. Figure 3 below is the common work definition model, objects shown as gray boxes are defined in Part 2 of this standard.

Work definitions are modeled as an abstract class. There are two types of work definitions that are modeled as non-abstract classes: work master and work directives.

Work masters are template information not associated with any specific job order. Work directives start as copies of work masters and are augmented with information for a specific job order.

A work definition may have a reference to an operations definition. In this situation the work definition defines the detailed steps needed to accomplish all or part of the operation.

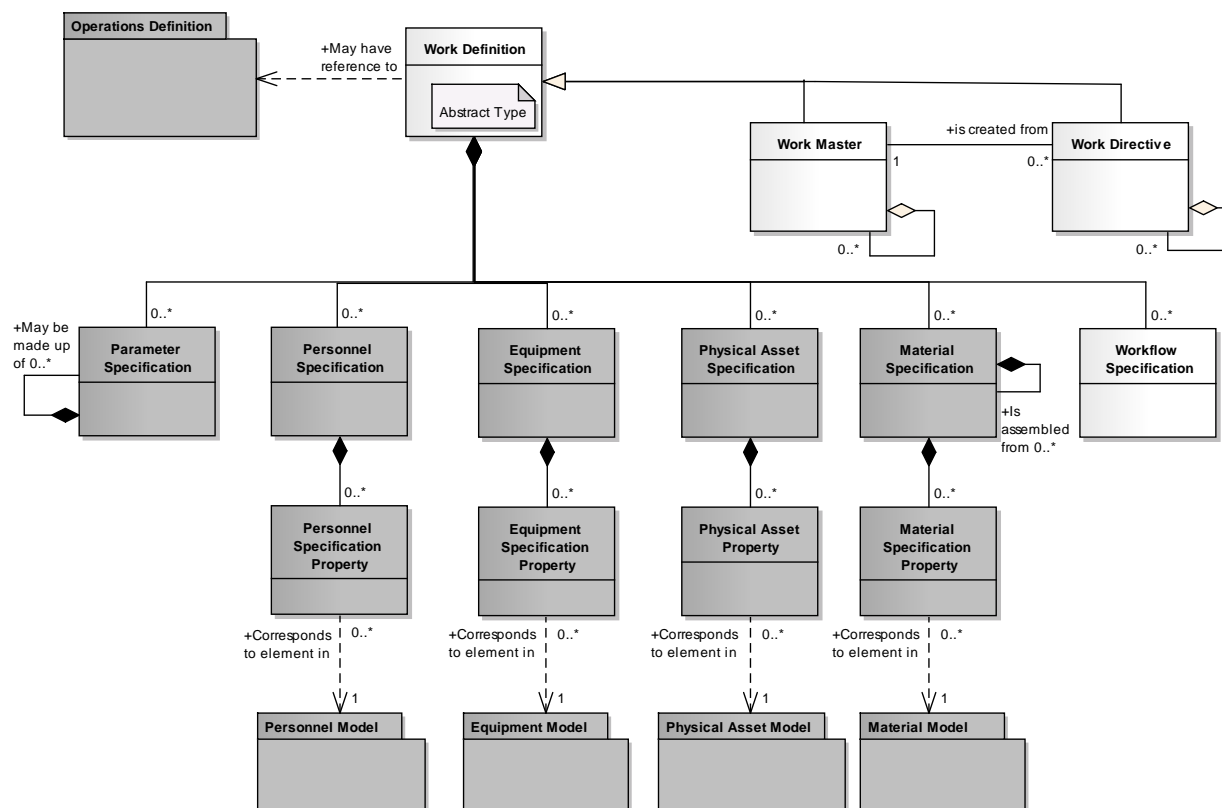


Figure 3 — Work definition model

7.2 Work master

The resources and routing required to perform a unit of work without reference to a specific job order shall be defined as a work master. A work master:

- Identifies material classes or material definitions
- Identifies nominal production run sizes (standard job order size)
- Identifies equipment classes for work centers and work units
- May identify other information required to execute the work definition for a job order.

EXAMPLE Instructions, automation procedures, SOPs, recipes, drawings, CNC programs, packaging specifications, label specifications, transition specification.

7.3 Work directive

The resources and instructions required to perform a unit of work for a specific job order shall be defined as a work directive. A work directive:

- Is created as a copy of a work master
- Is used to control one job order or part of a job order
- Defines exact batch sizes or production run sizes
- May identify material lots or material sublots for the job order
- May identify specific work centers and/or work units for the job order

There is one work directive for each executing job order. It contains the specific information required to perform the job order and the workflow process associated with the job order. The workflow process references a work master which define the exact instructions, rules, or other

information required to perform the work for the workflow process. Figure 4 illustrates the recursive nature of work masters and work directives.

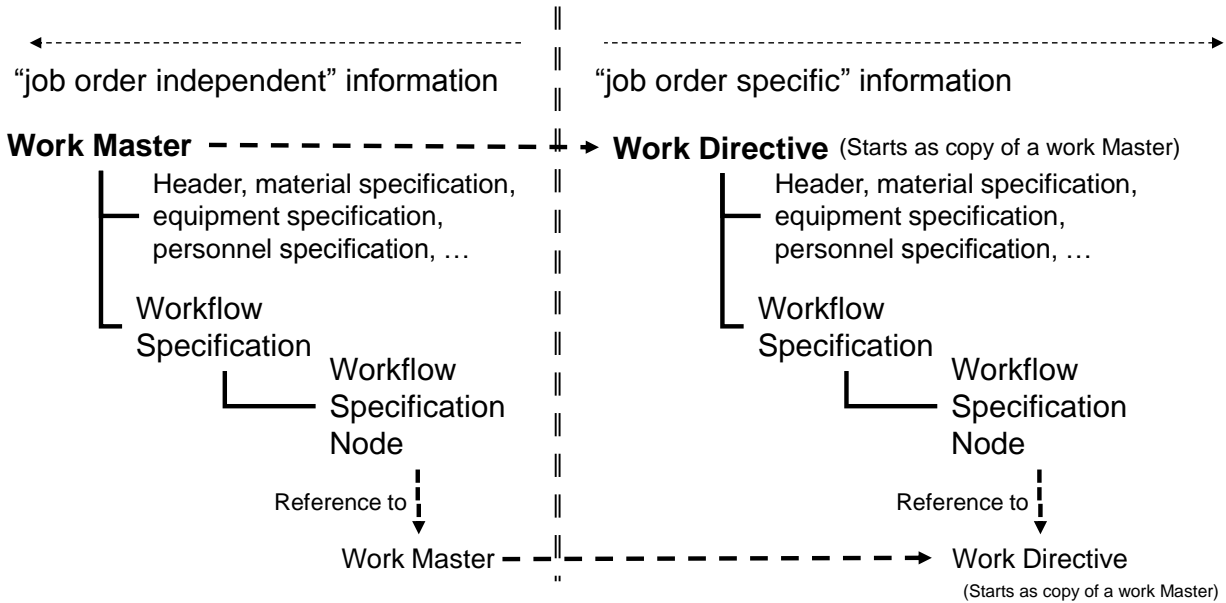


Figure 4 — Relationship of work master to work directive

NOTE The dashed vertical line in Figure 4 represents the tasks in *operations execution management* that create a **work directive** from a **work master** based on the requirements of the job list.

7.4 Work definition attributes

Table 12 defines the attributes for *work definition* objects. A work definition may contain work definitions, defining a hierarchy of work definitions.

Table 12 — Work definition attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Uniquely identifies the work definition.	Export quality widget	Medium size AC motor overhaul	Potency test procedure	Tank transfer procedure
Version	An identification of the version of the <i>work definition</i> . In cases where there are multiple versions of a <i>work definition</i> , then the version attribute shall contain the additional identification information to differentiate each version.	1.0	1.4	1.1	1.1
Description	Contains additional information and descriptions of the <i>work definition</i>	"Information defining resources required for work of a single 'export quality widget'".	For overhauls of motors less than 200 HP.	Test for potency of product	Movement of material from one tank to another
Work type	Describes the category of work Required attribute. Defined values are: production, maintenance, quality, inventory, or mixed. "Mixed" shall be used when the work definition contains resources and routing information required to perform several types of work..	Production	Maintenance	Quality	Inventory
Duration	Duration, if known.	25	4	1	40
Duration unit of measure	The units of measure of the duration, if defined.	Minutes	Hours	Day	Minutes

NOTE A MIMOSA *solution package* is the equivalent of a work definition for maintenance.

7.5 Parameter specification

The definition of this object and attributes for this object are defined in Part 2.

7.6 Personnel specification

The definition of this object and attributes for this object are defined in Part 2.

7.7 Personnel specification property

The definition of this object and attributes for this object are defined in Part 2.

7.8 Equipment specification

The definition of this object and attributes for this object are defined in Part 2.

7.9 Equipment specification property

The definition of this object and attributes for this object are defined in Part 2.

7.10 Physical asset specification

The definition of this object and attributes for this object are defined in Part 2.

7.11 Physical asset specification property

The definition of this object and attributes for this object are defined in Part 2.

7.12 Material specification

The definition of this object and attributes for this object are defined in Part 2.

7.13 Material specification property

The definition of this object and attributes for this object are defined in Part 2.

7.14 Workflow specification

7.14.1 Workflow specification model

A workflow specification shall be represented as a collection of nodes and connections. Each node is defined by a type definition, and each collection is defined by a type definition. A node may contain a reference to a work master.

Different workflow formats shall be represented as collections of node types and connection types. See Annex D and Annex E for examples of workflow specifications for different formats.

NOTE 1 Workflows are not unique to the manufacturing operations management domain. See the Business Process Model and Notation (BPMN) at <http://www.omg.org/spec/BPMN/> as a possible structure for a workflow format.

NOTE 2 The ISA-88 Recipe definitions are a workflow format. See the ANSI/ISA-88.00.01 definition for the recipe structure.

NOTE 3 Flowcharts are a workflow format.

NOTE 4 An IDEF (Integrated **DEF**inition) diagram may be a workflow format.

The workflow specification model is shown in Figure 5. The model is a general model for exchanging workflow definitions and is not unique to any specific workflow format. It represents the workflow as a collection of nodes and connections. The meaning of the nodes and connections is determined by the workflow format.

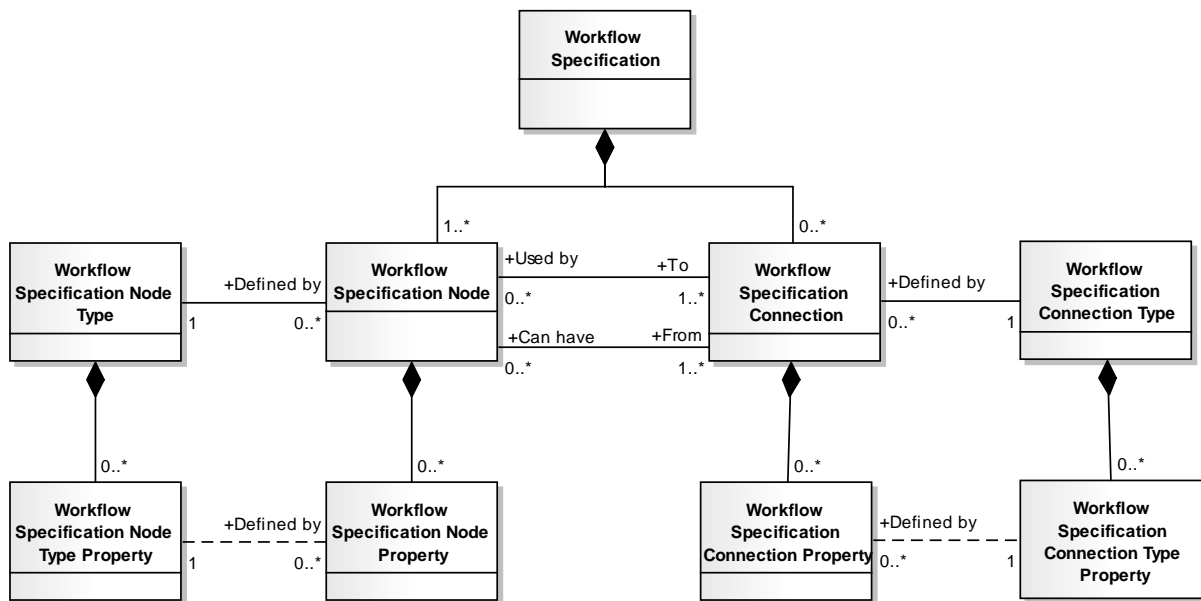


Figure 5 — Workflow specification model

EXAMPLE 1 Figure 6 is a workflow specification described in a BPMN format.

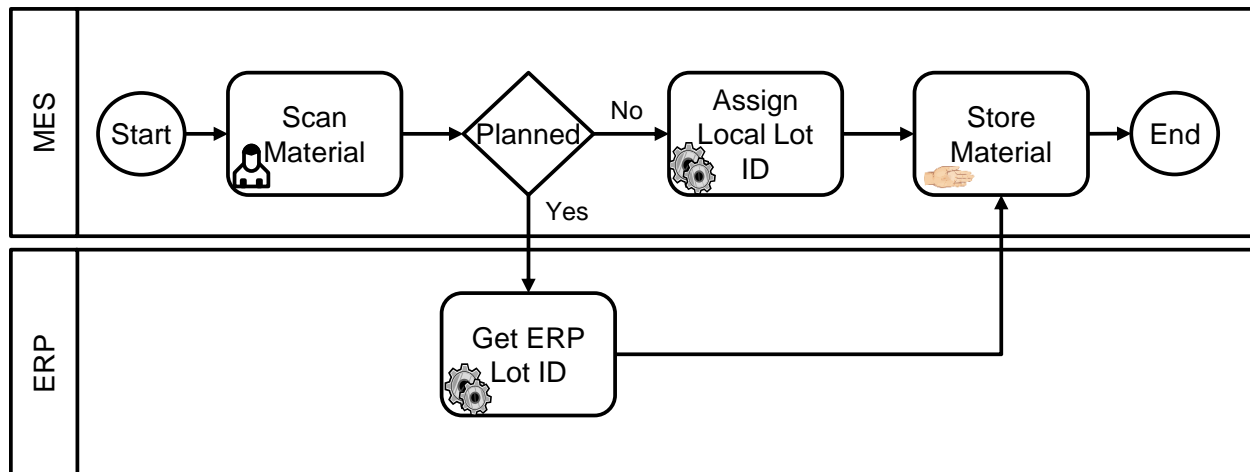


Figure 6 — Example of a workflow specification in BPMN format

Examples of representation in a workflow specification include:

- 1) A *workflow specification* containing two *workflow specification nodes*, one for the MES (Manufacturing Execution System) and one for the ERP (Enterprise Resource Planning). The MES and ERP nodes are of *workflow specification node type* = **POOL**
- 2) The MES node contains a *workflow specification* (identified here as MES_01)
- 3) MES_01 contains 6 *workflow specification nodes* and 6 *workflow specification connections*.
- 4) The Scan Material *workflow specification node* is of *workflow specification node type* = **TASK**.
- 5) The connection between Scan Material and Planned contains a FROM link to Scan Material and a TO link to Planned. The connection is of type **SEQUENCE FLOW**.
- 6) The ERP node contains a *workflow specification* (identified here as ERP_01)
- 7) ERP_01 contains 1 *workflow specification node* and 1 *workflow specification connection*.
- 8) The connection between Get ERP Lot ID and Store Material contains a FROM link to Get ERP Lot ID and a TO link to Store Material. The connection is of type **SEQUENCE FLOW**.

EXAMPLE 2 Figure 7 is a workflow described in a flowchart notation.

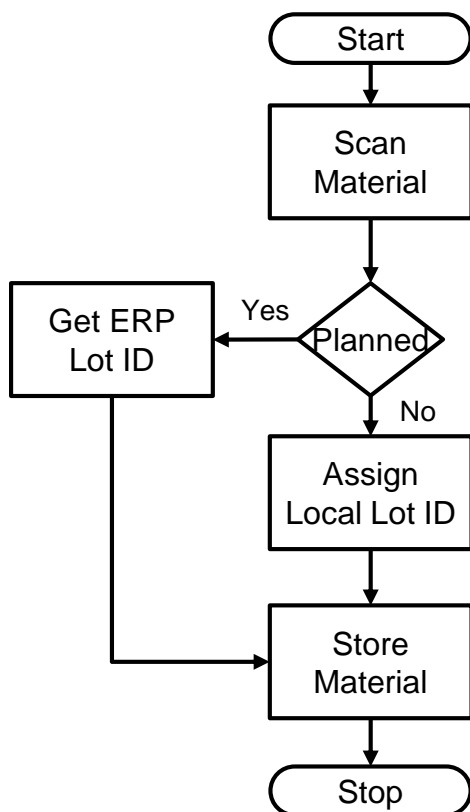


Figure 7 — Example of a workflow specification in flowchart format

Examples of representation in flowchart notation of a workflow specification include:

- 1) A *workflow specification* contains 7 *workflow specification nodes* and 7 *workflow specification connections*.
- 2) The Scan Material *workflow specification node* is of *workflow specification node type* = **ACTIVITY**.
- 3) The connection between Scan Material node and Planned node contains a FROM link to Scan Material and a TO link to Planned. The connection is of type **SEQUENCE**.
- 4) The connection between Get ERP Lot ID and Store Material contains a FROM link to Get ERP Lot ID and a TO link to Store Material. The connection is of type **SEQUENCE**.

7.14.2 Workflow specification attributes

A workflow specification shall be defined as a collection of workflow specification nodes and workflow specification connections.

A workflow specification shall contain at least one workflow specification node.

Table 13 defines the attributes for *workflow specification* objects

Table 13 — Workflow specification attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Uniquely identifies the workflow specification definition.	Make commercial grade widgets	Repair 20HP water pump	Test receiving material	Receiving materials
Description	Contains additional information and descriptions of the <i>workflow specification</i>	Instructions for making commercial grade widgets	Instructions for rebuild of 20HP water pump	Instructions for SOP33456	Hazardous materials receiving SOP

7.14.3 Workflow specification node

A workflow specification node is a reference to a work master, a contained workflow specification, or an entity used in the represented format (such as a decision element, transition condition, or starting point).

NOTE Nested workflow process structures, such as the ISA-88 recipe hierarchy, are represented through workflow specification nodes that contain other workflow specifications (a unit procedure contains the operation definition).

Table 14 defines the attributes for *workflow specification node* objects.

See Annex D and Annex E for examples.

Table 14 — Workflow specification node attributes

Attribute name	Description
ID	Uniquely identifies the workflow specification node definition.
Description	Contains additional information and descriptions of the <i>workflow specification node</i>
Work master ID	Contains an optional identification of a work master
Work definition ID	Contains an optional identification of a work definition

7.14.4 Workflow specification node property

A property of a workflow specification node shall be defined as a workflow specification node property.

Workflow specification node properties may be used to specify the defined properties that can be associated with the specific node type.

Table 15 defines the attributes for *workflow specification node property* objects.

See Annex D and Annex E for examples.

Table 15 — Workflow specification node property attributes

Attribute name	Description
ID	A unique identification of a property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

7.14.5 Workflow specification connection

A workflow specification connection represents a many-to-many link between workflow specification nodes.

NOTE The workflow specification connection type defines the allowed multiplicity of FROM and TO links.

Table 16 defines the attributes for *workflow specification connection* objects.

See Annex D and Annex E for examples.

Table 16 — Workflow specification connection attributes

Attribute name	Description
ID	Uniquely identifies the workflow specification connection definition.
Description	Contains additional information and descriptions of the <i>workflow specification connection</i>

EXAMPLE In a BPMN workflow structure, some of the following structuring elements would be represented as workflow specification connections:

Sequence Flow, Default Flow, Conditional Flow.

7.14.6 Workflow specification connection property

A property of a workflow specification connection shall be defined as a workflow specification connection property.

Workflow specification connection properties may be used to specify the defined properties that can be associated with the specific connection.

Table 17 defines the attributes for *workflow specification connection property* objects.

See Annex D and Annex E for examples.

Table 17 — Workflow specification connection property attributes

Attribute name	Description
ID	A unique identification of a property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

7.14.7 Workflow specification node type

A workflow specification node type defines the properties that can be associated with a specific workflow specification node.

Table 18 defines the attributes for *workflow specification node type* objects.
See Annex D and Annex E for examples.

Table 18 — Workflow specification node type attributes

Attribute name	Description
ID	Uniquely identifies the workflow specification node definition.
Description	Contains additional information and descriptions of the <i>workflow specification node</i>

7.14.8 Workflow specification node type property

A property of a workflow specification node type shall be defined as a workflow specification node type property.

Workflow specification node properties types specify the allowed properties that can be associated with a specific workflow specification node.

Table 19 defines the attributes for *workflow specification node type property* objects.

See Annex D and Annex E for examples.

Table 19 — Workflow specification node type property attributes

Attribute name	Description
ID	A unique identification of a property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

7.14.9 Workflow specification connection type

A workflow specification connection type specifies the permissible information on a connection.

Table 20 defines the attributes for *workflow specification connection* objects.

See Annex D and Annex E for examples.

Table 20 — Workflow specification connection type attributes

Attribute name	Description
ID	Uniquely identifies the workflow specification connection definition.
Description	Contains additional information and descriptions of the <i>workflow specification connection</i>
From multiplicity	Defines the multiplicity of the from connection: one, one or more, zero or more, or an allowed range
To multiplicity	Defines the multiplicity of the “to” connection: one, one or more, zero or more, or an allowed range

7.14.10 Workflow specification connection type property

A property of a workflow specification connection type shall be defined as a workflow specification connection type property.

Workflow specification connection properties types specify the allowed properties that can be associated with a specific workflow specification connections.

Table 21 defines the attributes for *workflow specification connection property* objects.

See Annex D and Annex E for examples.

Table 21 — Workflow specification connection property attributes

Attribute name	Description
ID	A unique identification of a property.
Description	Additional information about the property.
Value	The default value, set of values, or range of the property.
Value unit of measure	The unit of measure of the associated property value, if applicable.

8 Work schedule and job list models

8.1 Work schedule and job list

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

The work schedule may apply to scheduling of production, maintenance, quality test and inventory, or to other extended categories of activities.

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

Figure 8 is the work schedule and job list model, objects shown as gray boxes are defined in Part 2 of this standard.

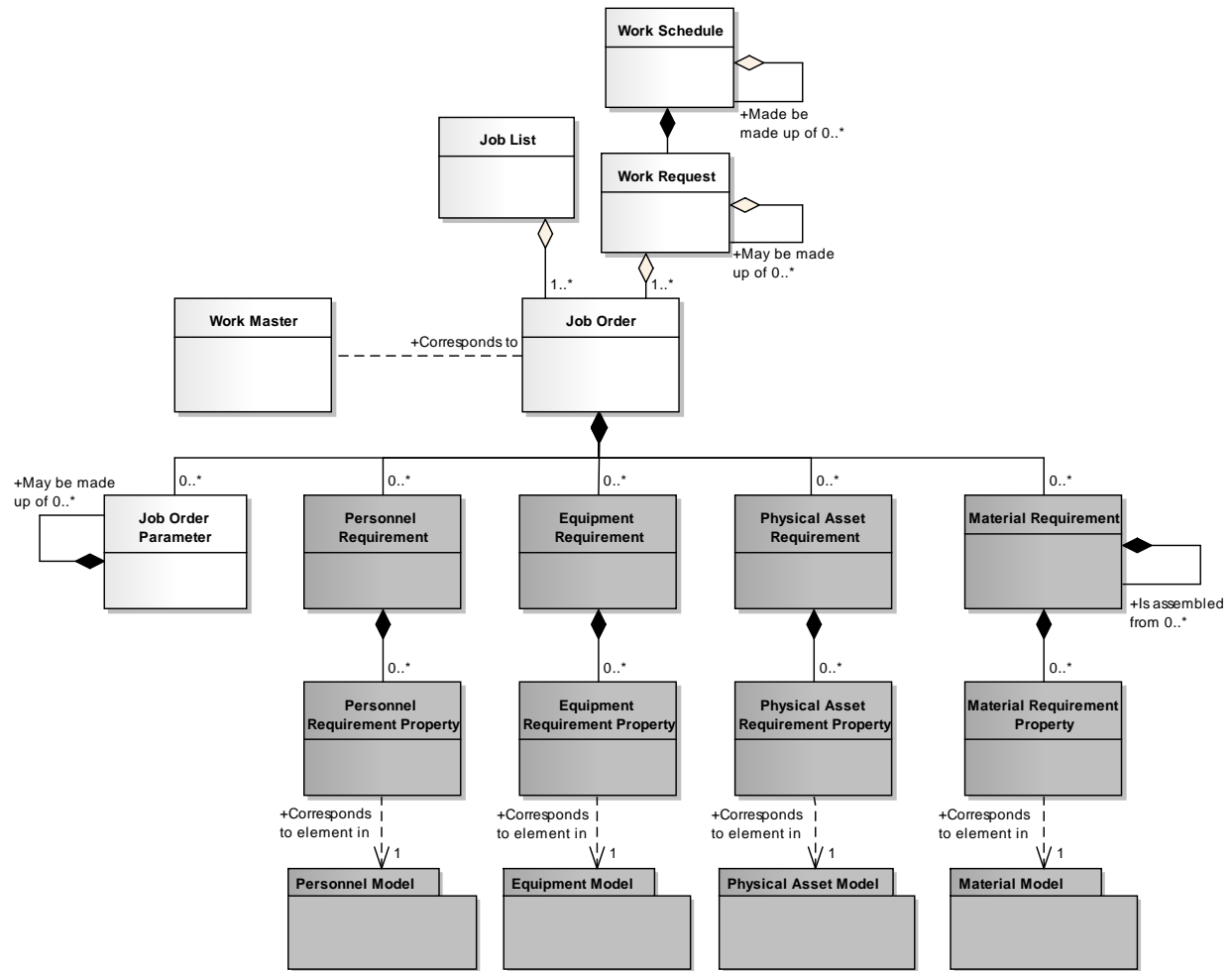


Figure 8 — Work schedule model

EXAMPLE 1 Figure 9 is an example of an operations schedule for a site.

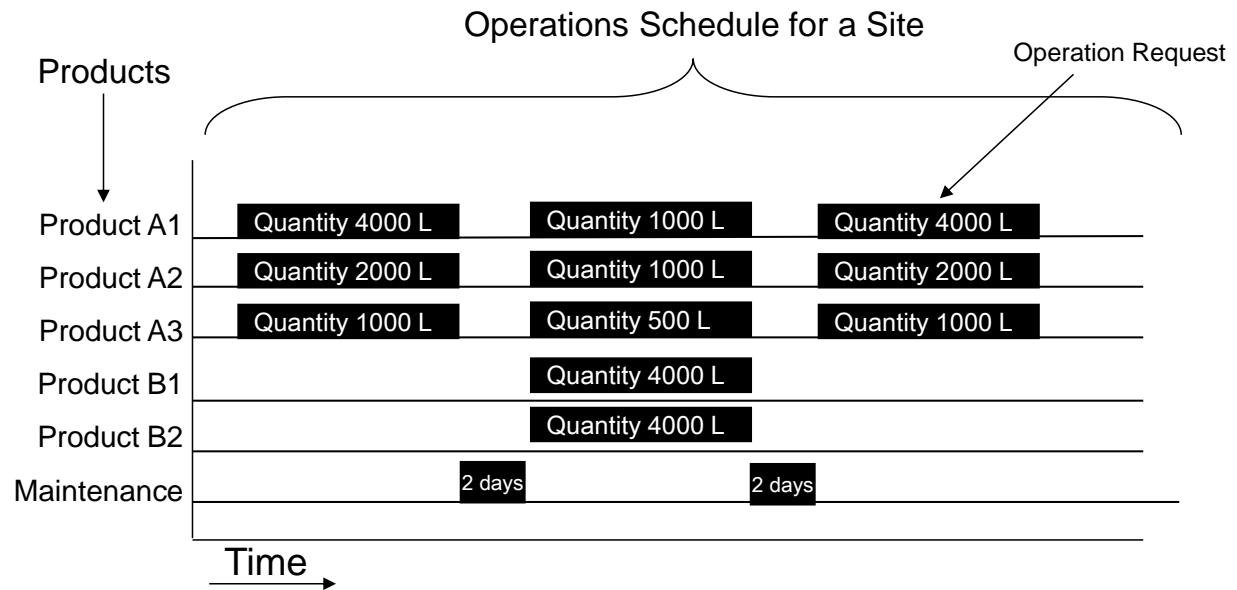


Figure 9 — Operations schedule for a site

EXAMPLE 2 Figure 10 is an example of a work schedule for an area in which one operation request is implemented in multiple work requests. In this example each work request is made up of multiple job orders.

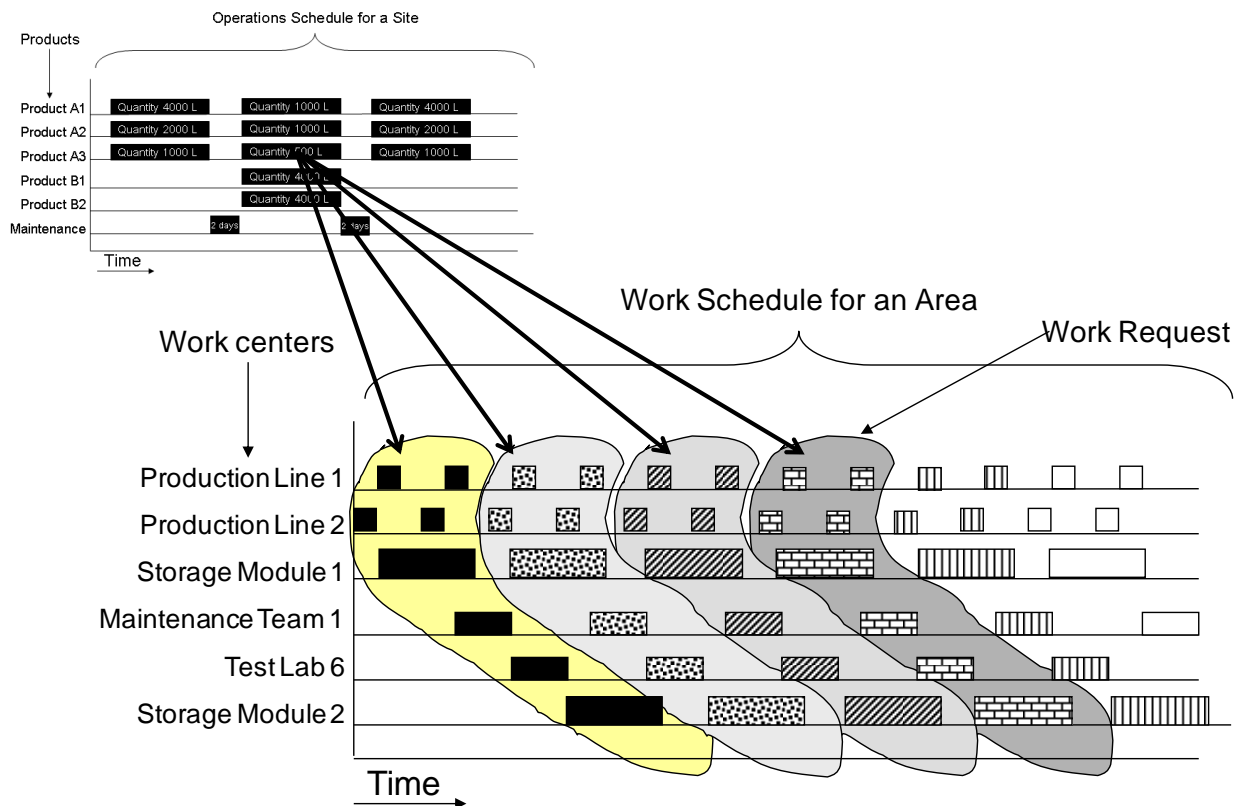


Figure 10 — Work schedule for an area

EXAMPLE 3 Figure 11 is an example of a work request with nested job orders and the associated work master for the job order. Each job order is associated with a work master.

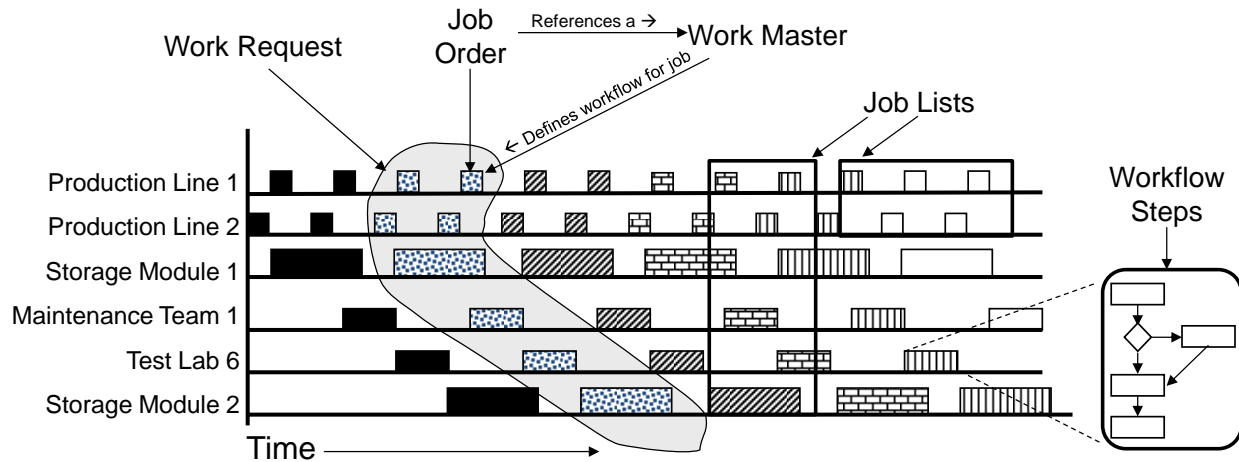


Figure 11 — Work request, job order, job list

Example 4 Figure 12 illustrates the use of a work request in a continuous process, where there may be no unused time between activities and where the job list can be the job orders required to perform a product slate switchover.

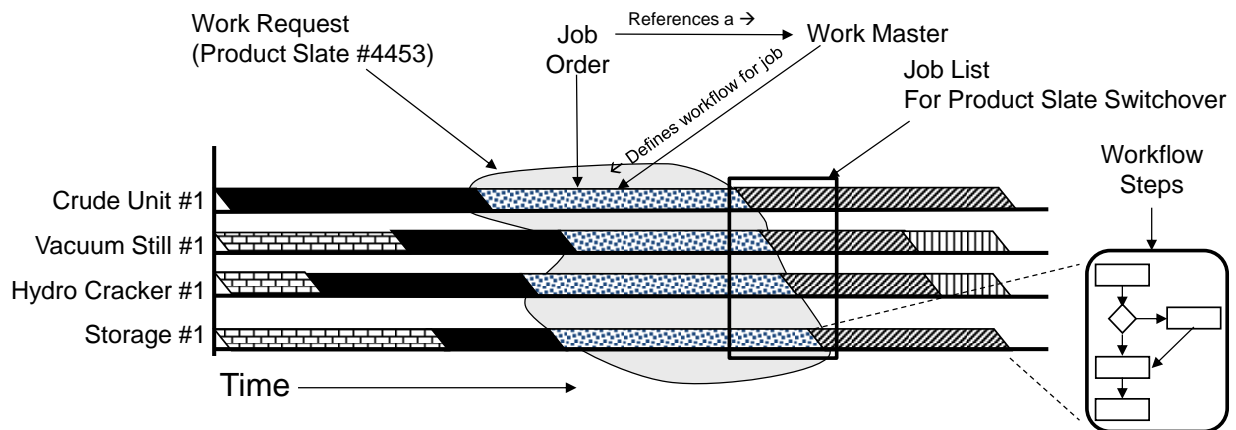


Figure 12 — Work request example for continuous processing

8.2 Work schedule attributes

Table 22 defines the attributes for *work schedule* object.

Table 22 — Work schedule attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the <i>work schedule</i> and could include version and revision identification. The ID shall be used in other parts of the model when the <i>work schedule</i> needs to be identified.	PMMFUF	MWOIDND	QNFKVUV	IECBDU
Work type	Describes the category of work. Required attribute Defined values are: production, maintenance, quality, inventory, and mixed. “Mixed” shall be used when the work schedule contains several types of work requests and/or segment requirements.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the <i>work schedule</i> .	“Widget manufacturing schedule.”	“Daily planned maintenance”	“Widget raw material testing schedule.”	“Widget raw material staging schedule.”
Start time	The starting time for the associated <i>work schedule</i> , if applicable.	10-28-2006	10-28-2006	10-28-2006	10-28-2006
End time	The ending time for the associated <i>work schedule</i> , if applicable.	10-30-2006	10-30-2006	10-30-2006	10-30-2006
Published date	The date and time on which the <i>work schedule</i> was published or generated.	12-30-1951 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B

NOTE A MIMOSA *segment request for work* and an *asset request for work* are the equivalent of a work request for either equipment or for a physical asset. The table of *request for work* is the equivalent of the work schedule.

8.3 Work request

A request for work for an element of work identified by work definition shall be defined as a work request. A work request contains the information required by manufacturing to fulfill scheduled work. This may be a subset of the business information, or it may contain additional information not normally used by the business system.

A work request shall contain at least one job order.

A work request may include

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

Additional information may be described in the associated Job Order's parameters, personnel requirements, equipment requirements, and material requirements.

A work request may be reported on by one or more work responses.

Table 23 defines the attributes for *work request* objects.

Table 23 — Work request attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the <i>work request</i> . The ID shall be used in other parts of the model when the <i>work request</i> needs to be identified.	1001091	CNC-PM-F1	SAMP#1A	BLEND KIT 101
Work type	Describes the category of work. Required attribute Defined values are: production, maintenance, quality, inventory, and mixed. "Mixed" shall be used when the work request contains several types of job orders.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the <i>work request</i> .	"Work request for export quality widgets for October 29, 1999."	Preventive maintenance of CNC machine for runtime exceeding 1500 hours.	Take batch sample at end of batch	Prepare dispense kit for batch
Start time	When work is to be started, if applicable.	1999-10-27 8:00 UTC	2011-03-07	N/A	8:00 AM
End time	When work is to be completed, if applicable.	1999-10-27 17:00 UTC	2011-03-10	N/A	8:30 AM
Priority	The priority of the request, if applicable.	Highest	Low	High	N/A
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Ware house B

8.4 Job list model

A job list shall be defined as a collection of job orders for a specific period of time and selected workcenters or other resources. A job list may be considered as a slice of work schedules.

A job list may contain job orders from multiple work requests and work schedules. The model for job lists is shown in Figure 8, objects shown as gray boxes are defined in Part 2 of this standard.

NOTE 1 The determination of how to take a slice of work schedules to is not defined in this standard.

EXAMPLE 1 Slices may be by time, for example, all job orders for the first shift for a specific day, or by equipment and time such as all job orders for production line 1 for the next week.

EXAMPLE 2 Slices may be by resource, for example all jobs for a specific workcell for some period of time.

NOTE 2 The level of granularity of a job list is determined by the application. It may be very granular and refer to level 2 equipment, or it may be less granular and refer to equipment at the planning level.

Job lists may contain a sequence of job orders. In this case the order in which job orders are sequenced is embedded in the job list entry start rules.

8.5 Job list attributes

Table 24 lists the attributes of *job list*. *Job list* has the same attributes as a work requests, because it is a slice of a work schedule.

Table 24 — Job list attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the <i>job list</i> and could include version and revision identification. The ID shall be used in other parts of the model when the <i>job list</i> needs to be identified.	PMMFUF	MWOIDND	QNFKVUV	IECBDU
Work type	Describes the category of work. Required attribute Defined values are: production, maintenance, quality, inventory, and mixed. “Mixed” shall be used when the work schedule contains several types of job orders.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the <i>job list</i> .	“Widget manufacturing schedule.”	“Daily planned maintenance”	“Widget raw material testing schedule.”	“Widget raw material staging schedule.”
Start time	The starting time for the associated <i>job list</i> , if applicable.	10-28-2006	10-28-2006	10-28-2006	10-28-2006
End time	The ending time for the associated <i>job list</i> , if applicable.	10-30-2006	10-30-2006	10-30-2006	10-30-2006
Published date	The date and time on which the <i>job list</i> was published or generated.	12-30-1951 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC	10-17-2005 18:30 UTC
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B

8.6 Job order

The smallest unit of work in a job list and a work request shall be defined as a job order. A job order references an associated work master. The work master is a type of work definition.

Table 25 lists the attributes of *job order*. It has attributes to contain information added by the dispatching activities.

Table 25 — Job order attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the <i>job order</i> . The ID shall be used in other parts of the model when the <i>job order</i> needs to be identified.	1001091	DO4833-A	EE90989	38483ED
Work type	Describes the category of work. Required attribute Defined values are: production, maintenance, quality, inventory, and mixed. “Mixed” shall be used when the work request contains several types of segment requirements.	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the <i>job order</i> .	“Work request for export quality widgets for October 29, 1999.”	“Work order to repair shear”	“Ambient temperature sampling procedure”	“Stage material for production”
Work master	Identifies the associated <i>work master</i> and version to be used, if applicable.	Export Quality Widget, V010	Repair Shear	Raw Material Sampling Procedure 943	Kit Assembly A84
Start time	When work is to be started, if applicable.	1999-10-27 8:00 UTC	2014-03-07 10:00 UTC	2010-04-27 20:30	2011-01-20 14:45 UTC-10:00
End time	When work is to be completed, if applicable.	1999-10-27 17:00 UTC	2014-03-08 08:00 UTC	2010-06-27 17:00	2011-01-27 09:30 UTC-10:00
Priority	The priority of the request, if applicable.	Highest	3	A	Medium
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	Lid Press Asset ID 13465	Test Cell 4 Receiving	Warehouse B
Command	Identifies the action the execution management activity is to perform on the job order.	Start Hold Cancel Abort Stop	Start Hold Cancel Abort Stop	Start Hold Cancel Abort Stop	Start Hold Cancel Abort Stop
Dispatch status	Identifies the status of the entry from the perspective of the dispatch activity. NOTE: This status is similar to what a planner would write on his whiteboard to track a job order.	Dispatched Pending Held Cancelled Delayed Completed	Dispatched Acknowledged In process Waiting for part	Dispatched Sampling Lab test in progress	Dispatched In transit In receipt Staged

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
Command rule	Instruction to execution management activities specifying conditions to execute the command.	Equipment is clean <i>After job order WED89 is complete</i>	Parts available and equipment not in production	Request from production Request from receiving	Stock out condition
Work master ID	A work master the job order references.	845714581	DFIE8948-A	RRFG45	4534KR

8.7 Job order parameter

Information to be exchanged which cannot be mapped as personnel, equipment, physical asset or material properties shall be known as work request parameters.

The attributes for work request parameter are the same as those for segment parameter defined in Part 2 of this standard.

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

8.8 Personnel requirement

The definition of this object and attributes for this object are defined in Part 2.

8.9 Personnel requirement property

The definition of this object and attributes for this object are defined in Part 2.

8.10 Equipment requirement

The definition of this object and attributes for this object are defined in Part 2.

8.11 Equipment requirement property

The attributes for equipment requirement property are defined in Part 2 of this standard.

8.12 Physical asset requirement

The definition of this object and attributes for this object are defined in Part 2.

8.13 Physical asset requirement property

The attributes for physical asset requirement property are defined in Part 2 of this standard.

8.14 Material requirement

The definition of this object and attributes for this object are defined in Part 2.

8.15 Material requirement property

The definition of this object and attributes for this object are defined in Part 2.

9 Work performance model

9.1 Work performance

Work performance shall be defined as a collection of work responses that is a report on requested manufacturing requests. Work responses are responses from manufacturing that are associated with a work request. There may be one or more work responses for a single work request if the manufacturing facility needs to split the work request into smaller elements.

Figure 13 is the work performance model, objects shown as gray boxes are defined in Part 2 of this standard.

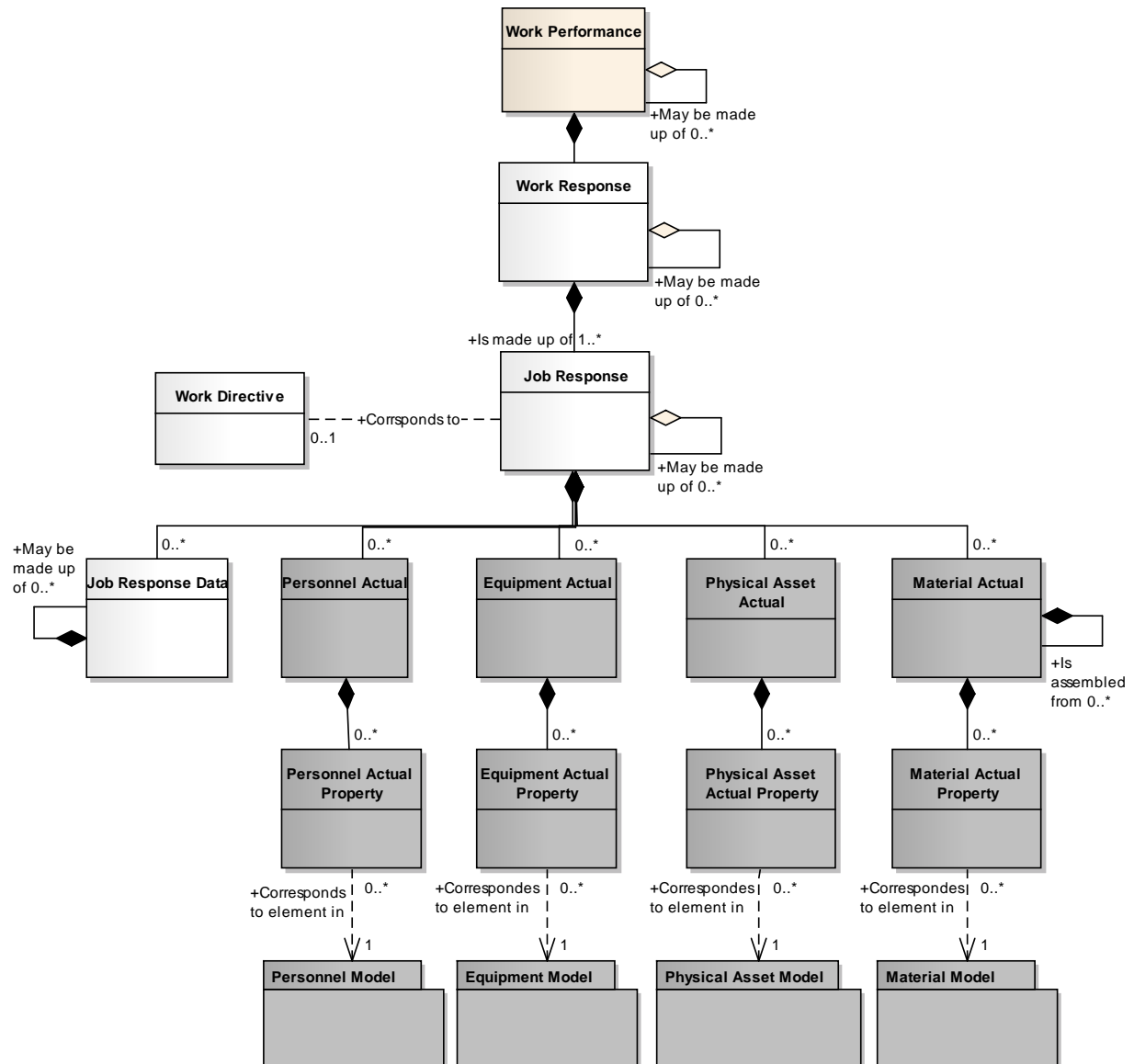


Figure 13 — Work performance model

9.2 Work performance attributes

Table 26 defines the attributes for *work performance* objects.

Table 26 — Work performance attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the <i>work performance</i> and could include version and revision identification. The ID shall be used in other parts of the model when the <i>work performance</i> needs to be identified.	1999-10-27-A15	CNC-PM-20110307-13465	B12345-S01	B12345-KIT101-A
Work type	Describes the category of work	Production	Maintenance	Quality	Inventory
Description	Contains additional information and descriptions of the <i>work performance</i> .	"Work performance report on Oct 27, 1999 work schedule."	Preventive maintenance performed on CNC machine	Production sample for batch 12345	Dispense kit for batch 12345
Work schedule	An identification of the associated <i>work schedule</i> , if applicable. <i>Work performance</i> may not relate to a <i>work schedule</i> , it may be a report on all work for a specific time, or reported on by plant floor events.	1999-10-27-A15	07MAR2011-CNC-13465	BATCH 12345 SAMPLE #1	BATCH 12345 KIT #1
Start time	The starting time of the associated <i>work performance</i> , if applicable.	10-28-1999	2011-03-07 09:31	N/A	2011-03-07 08:01
End time	The ending time of the associated <i>work performance</i> , if applicable.	10-30-1999	2011-03-10 11:15	N/A	2011-03-07 08:31
Published date	The date and time on which the <i>work performance</i> was published or generated.	10-27-1999 13:42 EST	2011-03-10 13:21	2009-12-14 13:31 PT	2011-03-07 08:33
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Warehouse B

9.3 Work response

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

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

Table 27 defines the attributes for *work response* objects.

Table 27 — Work response attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification within the associated <i>work performance</i> . The ID shall be used in other parts of the model when the <i>work response</i> needs to be identified.	1001091	R-CNC-PM-20110307-13465	B12345-S01-RESP	B12345-KIT101-R
Work type	Describes the category of work	Production	Maintenance	Quality	Inventory
Work request	An identification of the associated <i>work request</i> , if applicable. <i>Work response</i> may not relate to a <i>work request</i> , it may be a report on all work for a specific time, or reported on by plant floor events.	1001091	CNC-PM-20110307-13465	B12345-S01	B12345-KIT101-A
Start time	The starting time of this <i>work response</i> .	1999-10-27 8:33 UTC	2011-03-07 09:31	2011-03-10 15:12	2011-03-07 08:01
End time	The ending time of this <i>work response</i> .	1999-10-27 16:55 UTC	2011-03-10 11:15	2011-03-10 18:00	2011-03-07 08:31
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Zone B

9.4 Job response

The responses from manufacturing that are associated with a job order shall be defined as a job response. There may be one or more job responses for a single job order if the manufacturing facility needs to split the job order into smaller elements of work.

A job order may include the status of the request, such as the percentage complete, a finished status, or an aborted status.

Table 28 defines the attributes for *job response* objects.

Table 28 defines the attributes for *job response* objects.

Table 28 — Job response attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification within the associated <i>work response</i> . The ID shall be used in other parts of the model when the <i>work response</i> needs to be identified.	1001091	R-CNC-PM-20110307-13465	B12345-S01-RESP	B12345-KIT101-R
Work type	Describes the category of work	Production	Maintenance	Quality	Inventory
Job order	An identification of the associated <i>job order</i> , if applicable. <i>Job responses</i> may not relate to a <i>job order</i> , it may be a report on all work for a specific time, or reported on by plant floor events.	1001091	CNC-PM-20110307-13465	B12345-S01	B12345-KIT101-A
Work directive	Identifies the associated <i>work directive</i> that was used, if applicable. This may not match the request, if alternate specifications are allowed.	Export quality widget	Preventive maintenance of CNC machine	Take batch sample	Prepare kit
Work directive version	Identifies the version of the associated <i>work directive</i> that was used, if applicable.	1.0	V1.0	V2.0	VER A
Start time	The starting time of this <i>job response</i> .	1999-10-27 8:33 UTC	2011-03-07 09:31	2011-03-10 15:12	2011-03-07 08:01
End time	The ending time of this <i>job response</i> .	1999-10-27 16:55 UTC	2011-03-10 11:15	2011-03-10 18:00	2011-03-07 08:31
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy.	East Wing Manufacturing Line #2	CNC Machine Asset ID 13465	Test Cell 4 Receiving	Zone B

9.5 Job response data

Other information related to the actual work made shall be presented as job response data.

The attributes for job response data are defined in Part 2 of this standard as segment data.

9.6 Personnel actual

The definition of this object and attributes for this object are defined in Part 2.

9.7 Personnel actual property

The definition of this object and attributes for this object are defined in Part 2.

9.8 Equipment actual

The definition of this object and attributes for this object are defined in Part 2.

9.9 Equipment actual property

The definition of this object and attributes for this object are defined in Part 2.

9.10 Physical asset actual

The definition of this object and attributes for this object are defined in Part 2.

9.11 Physical asset actual property

The definition of this object and attributes for this object are defined in Part 2.

9.12 Material actual

The definition of this object and attributes for this object are defined in Part 2.

9.13 Material actual property

The definition of this object and attributes for this object are defined in Part 2.

10 Work capability model

10.1 Work capability

The collection of information about all resources for work for selected future and past times shall be defined as work capability information. This is made up of information about equipment, material, personnel, physical asset, and work master capabilities. Work capability describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

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

Figure 14 is the work capability model that applies to production, maintenance, quality test and inventory, objects shown as gray boxes are defined in Part 2 of this standard.

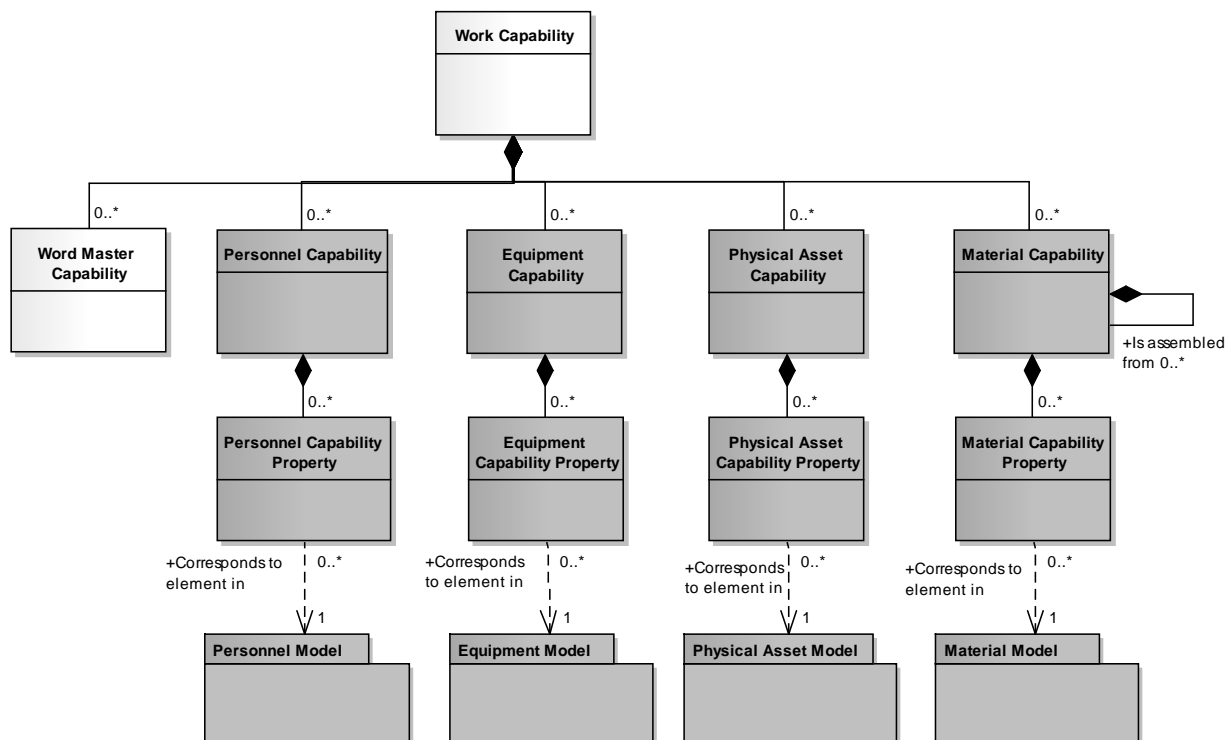


Figure 14 — Work capability model

10.2 Work capability attributes

Table 29 defines the attributes for *work capability* objects.

Table 29 — Work capability attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Defines a unique instance of a work capability for a specified element of the equipment hierarchy model [Part 1 Clause 5.2] (<i>enterprise, site, area, work center, or work unit</i>).	1999/12/30-HPC52	HHG6778	LAB6678	AGV556
Description	Contains additional information and descriptions of the <i>work capability</i> definition.	"One day's work capacity for the Boston Widget Company."	Motor Shop Capacity, Week 15	Lab Centrifuge Capacity	Pallet movement capacity
Capacity type	The capacity type: used, unused, total, available, unattainable, or committed.	Available	Total	Committed	Available
Reason	Defines the reason for the capability type. Example 1: If committed, then committed for work or for maintenance, or if unattainable, then the reason for the unavailability. Example 2: If unused capacity, then the reason for the capacity was unused, such as a specific equipment failure or unacceptable product quality	Available for work	Total hours of motor maintenance	Stability tests	Uncommitted AGVs
Confidence factor	A measure of the confidence of the capacity value. Example 3: A percentage value representing the confidence of the capacity	90%	100%	100%	75%
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy. Zero or more as required to identify the specific scope of the work capability definition.	Boston Widget Company	Boston Widget Company	Boston Widget Company	Boston Widget Company
Start time	The starting date and time of the work capability.	2015-12-29 11:59	2011-04-03 12:00	2011-04-03 12:00	2011-04-03 12:00
End time	The ending date and time of the work capability.	2015-12-30 12:00	2011-04-09 11:59	2011-04-09 11:59	2011-04-09 11:59
Published date	The date and time on which the <i>work capability</i> was published or generated.	2015-11-03 13:55	2011-04-01 8:00	2011-04-01 8:00	2011-04-01 8:00

10.3 Personnel capability

The definition of this object and attributes for this object are defined in Part 2.

10.4 Personnel capability property

The definition of this object and attributes for this object are defined in Part 2.

10.5 Equipment capability

The definition of this object and attributes for this object are defined in Part 2.

10.6 Equipment capability property

The definition of this object and attributes for this object are defined in Part 2.

10.7 Physical asset capability

The definition of this object and attributes for this object are defined in Part 2.

10.8 Physical asset capability property

The definition of this object and attributes for this object are defined in Part 2.

10.9 Material capability

The definition of this object and attributes for this object are defined in Part 2.

10.10 Material capability property

The definition of this object and attributes for this object are defined in Part 2.

11 Work master capability model**11.1 Work master capability**

A representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a given work master for a specific time shall be defined as a work master capability, as shown in Figure 15, objects shown as gray boxes are defined in Part 2 of this standard.

A work master capability is a representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that are committed, available, or unavailable for a defined work master for a specific time.

Work master capability shall identify

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

Work master capabilities shall be made up of

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

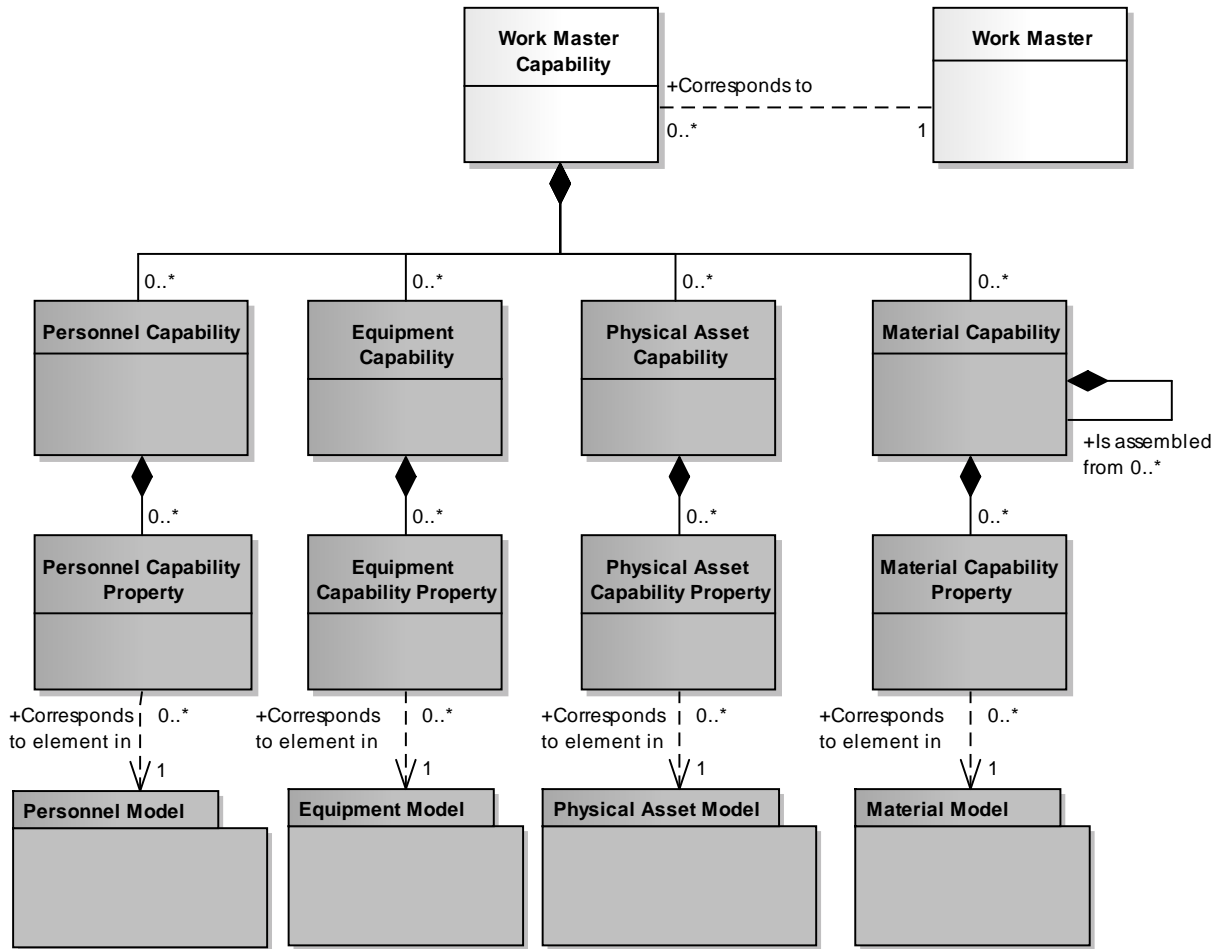


Figure 15 — Work master capability object model

11.2 Work master capability attributes

ANSI/ISA-95.00.04-2012

Table 30 lists the attributes of *work master capability*. *Work master capability* has an equivalent structure to the personnel, equipment and material structure of *work capability*, except the *work master capability* is defined for a specific *work master*.

Table 30 — Work master capability attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	A unique identification of the <i>work master capability</i> .	A7756	20121111	20121111 Q	
Description	Contains additional information and descriptions of the <i>work master capability</i> definition.	“Defines the available capability for the widget assembly process segment”	Calibration of custody transfer gas flow meters	Hazardous material incoming inspection	Movement of hazardous material to warehouse
Work master	Identifies the <i>work master</i> .	Widget assembly	CTCF calibration	HMI	Fork truck movement
Capacity type	The capacity type: available, unattainable, or committed.	Available	Committed	Available	Available
Reason	Gives the reason for the capacity type.	Available for production	Required by regulation	Available from scheduling	Available for scheduling
Hierarchy scope	Identifies where the exchanged information fits within the role based equipment hierarchy. If omitted, then the capability is associated to the parent <i>work master capability</i> hierarchy scope. Zero or more as required to identify the specific scope of the production capability definition.	Production Line #15	West Production Site	Receiving Warehouse 13	Receiving Warehouse 13
Start time	The starting time of the time span defining the capacity type. If omitted, then the capability is associated to the parent <i>work master capability</i> start time.	2013-12-30 11:59	2012-11-11 11:59	2012-11-11 11:59	2012-11-11 11:59
End time	The ending time of the time span defining the capacity type. If omitted, then the capability is associated to the parent <i>work master capability</i> end time.	2014-01-01 12:00	2012-11-12 11:59	2012-11-12 11:59	2012-11-12 11:59

11.3 Personnel capability

The definition of this object and attributes for this object are defined in Part 2.

11.4 Personnel capability property

The definition of this object and attributes for this object are defined in Part 2.

11.5 Equipment capability

The definition of this object and attributes for this object are defined in Part 2.

11.6 Equipment capability property

The definition of this object and attributes for this object are defined in Part 2.

11.7 Physical asset capability

The definition of this object and attributes for this object are defined in Part 2.

11.8 Physical asset capability property

The definition of this object and attributes for this object are defined in Part 2.

11.9 Material capability

The definition of this object and attributes for this object are defined in Part 2.

11.10 Material capability property

The definition of this object and attributes for this object are defined in Part 2.

12 KPI model

12.1 KPI

Values that have a business or operational value related to a measure of performance shall be defined as KPIs (key performance indicators). KPIs are registered and defined. Registered KPI values are exchanged on a regular or event basis. See ISO 22400 for a definition of the KPI object model, attributes, and standard KPIs.

13 Work alerts model

13.1 Work alert

A notification of a Level 3 event shall be defined as a work alert. Not all events warrant creating a work alert. A work alert does not require acknowledgement. If acknowledgement is needed, then an alarm model should be used (see ANSI/ISA-18.02-2009, Management of Alarm Systems for the Process Industries, for information on alarms). Work alerts may be generated by any Level 3 activity.

This Part 4 standard defines the data exchanged within Level 3 for a work alert. Work alert definitions are descriptions of the available types of work alerts.

- NOTE 1 The detailed configuration data for work alerts, such as trigger conditions, registration of recipients and actions to be taken upon receipt are out of the scope of this Part 4 standard.
- NOTE 2 Work alerts differ from work KPIs in that the primary content of a work alert is the contextual information required to convey that an event has occurred.
- EXAMPLE 1 This is similar to a "gate change alert" emailed to a traveler if a plane gate change occurs. It indicates a potentially significant event but does not require any response or action.
- EXAMPLE 2 A calculation or checking of a work KPI may trigger a work alert, but other events may also trigger a work alert.
- EXAMPLE 3 A work alert that indicates the completion of a production run may be a trigger to start the execution of a work flow.
- EXAMPLE 4 A work flow event, such as the expiration of a deadline timer, may trigger a work alert.

Figure 16 is the work alert model.

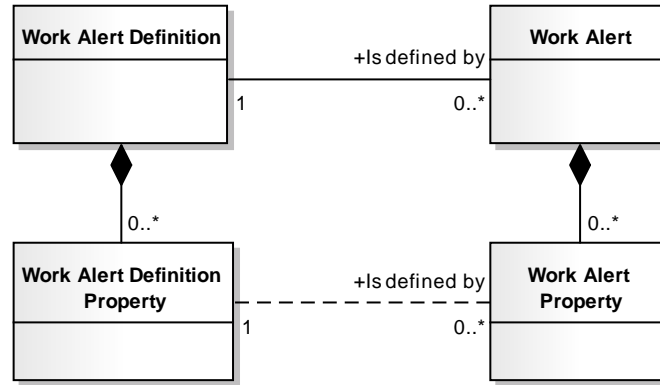


Figure 16 — Work alert model

13.2 Work alert definition

Table 31 lists the attributes of *work alert definition*.

Table 31 — Work alert definition attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Unique identification of the <i>work alert definition</i> .	P_0004293	M32D	834	Inven88
Description	Contains additional information and descriptions of the <i>work alert definition</i> .	Notification of job order started	Reminder that PM is overdue	Test setup complete	Shipment arrived
Priority	List of the priorities that act as a guide to the relative level of importance of a <i>work alert</i>	{1,2,3}	{Low, Medium, High}	{Information, Error}	{1..10}
Category	General grouping associated with a <i>work alert definition</i> .	Scheduling	PM	Lab	Receiving

13.3 Work alert definition property

Table 32 lists the attributes of *work alert definition property*.

Table 32 — Work alert definition property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific property, unique under the scope of the parent <i>work alert definition</i> object.	Job order ID	Physical asset ID	Test ID	Quantity
Description	Additional information and description about the <i>work alert definition property</i> .	Identification of the associated job order	Identification of the equipment to be maintained	Identification of the test type	Quantity of material received
Value	The value, set of values, or range of the property. This presents a range of possible numeric values, a list of possible values, or it may be empty if any value is valid.	Not applicable	Not applicable	0..99999	0..20000
Value unit of measure	The unit of measure of the associated property values, if applicable.	Not applicable	Not applicable	Not applicable	Kg

EXAMPLE 1 Example properties for work alerts:

Property	Description
Asset key	A unique data source identifier of the asset associated with the alert
Help	Text to provide additional information about the alert and may include information about the cause of the problem and suggestions on how to fix the problem

13.4 Work alert attributes

Table 33 lists the attributes of *work alert* attributes.

Table 33 — Work alert attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	Unique identification of the <i>work alert</i>	49293847523	M-53A	ER4232	INV-FG
Message text	Textual content of the <i>work alert</i>	Vacuum gas unit switched to feedstock ABC	Overdue PM on compressor 105, WO # 2843	Test #88765 ready	Material arrived
Timestamp	Timestamp the work alert was generated.	Mon August 16 at 01:36 PM	2014-03-07 10:00 UTC	2010-04-27 10:30	2011-01-20 14:45 UTC-10:00
Priority	Guide to the relative level of importance of the value for the <i>work alert</i> NOTE 1 No standard priority types are defined in this standard	1	Medium	Informa-tional	8
Category	General grouping associated with a <i>work alert</i> NOTE 2 No standard categories are defined in this standard	Scheduling	PM	Lab	Receiving

13.5 Work alert property

Table 34 lists the attributes of *work alert properties*.

Table 34 — Work alert property attributes

Attribute name	Description	Production examples	Maintenance examples	Quality examples	Inventory examples
ID	An identification of the specific <i>work alert property</i> .	Job order ID	Physical asset ID	Test ID	Quantity of material received
Description	Additional information about the <i>work alert property</i> .	On time switch over	Scheduled maintenance	Test ready	Not applicable
Value	The value, set of values, or range of the property.	99387A	105	88765	1856
Value unit of measure	The unit of measure of the associated property value, if applicable.	Not applicable	Not applicable	Not applicable	Kg

14 Object lists and relationships

Figure 17 provides an informative illustration of how some of the object models inter-relate.

NOTE 1 The work alert and work KPI models are not directly related to the other models.

NOTE 2 The resource relationship model is not shown because it relates to the resources (defined in Part 2).

The slanted rectangles in Figure 17 represent any of the resources (personnel, equipment, physical asset, or material) or properties of the resources.

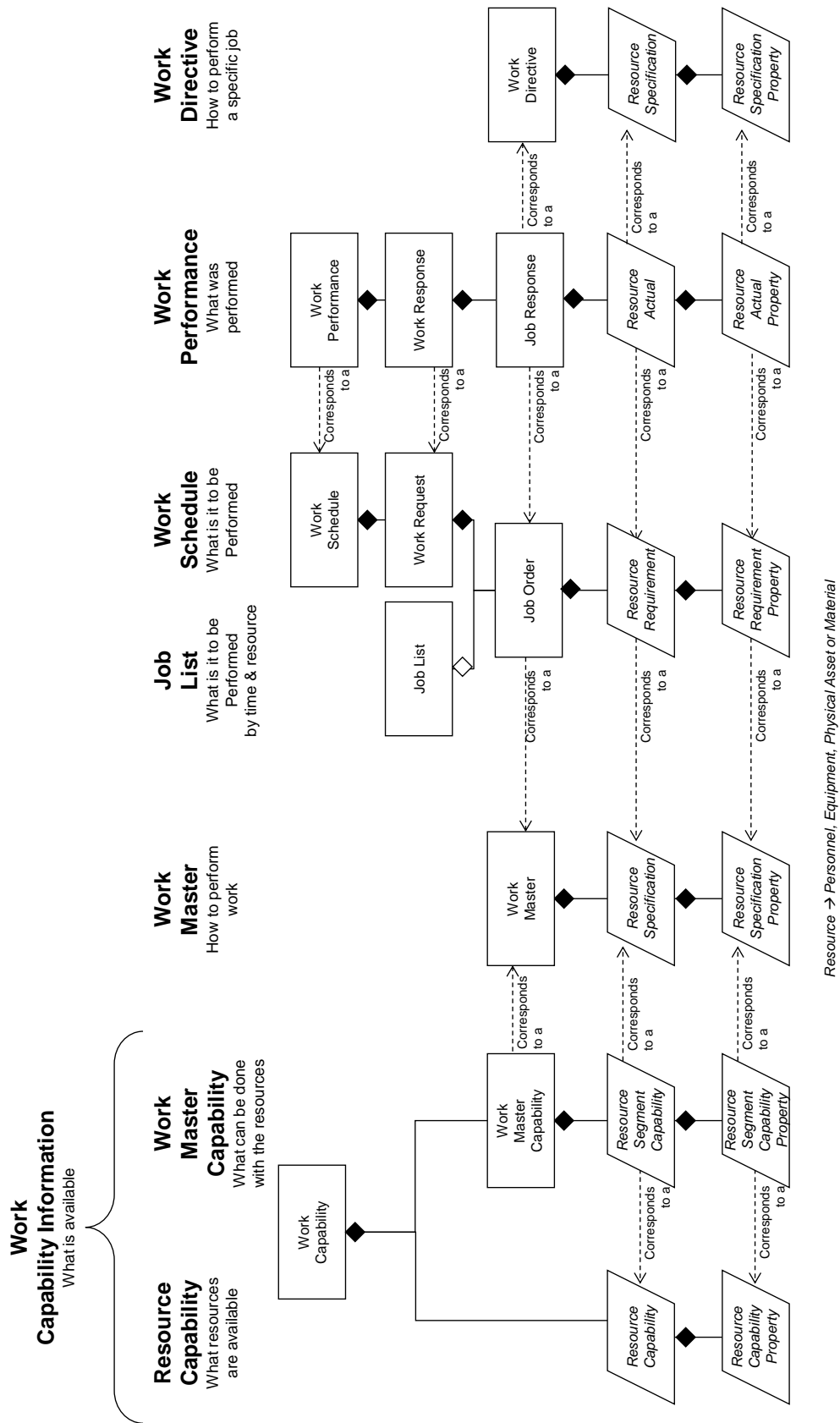


Figure 17 — Relationship between models

Table 35 presents the objects defined in this standard and the associated model.

Table 35 — Objects and models

Object	Model
From resource reference	Resource relationship network model
From resource reference property	Resource relationship network model
Job list	Work schedule model
Job order	Work schedule model
Job order parameter	Work schedule model
Job response	Work performance model
Job response data	Work performance model
Resource network connection	Resource relationship network model
Resource network connection property	Resource relationship network model
Resource network connection type	Resource relationship network model
Resource network connection type property	Resource relationship network model
Resource relationship network	Resource relationship network model
To resource reference	Resource relationship network model
To resource reference property	Resource relationship network model
Work alert	Work alert model
Work alert definition	Work alert model
Work alert definition property	Work alert model
Work alert property	Work alert model
Work capability	Work capability model
Work definition	Work definition model
Work directive	Work definition model
Work master	Work definition model
Work master capability	Work master capability model
Work performance	Work performance model
Work request	Work schedule model
Work response	Work performance model
Work schedule	Work schedule model

Object	Model
Work specification	Work definition model
Workflow specification	Workflow specification model
Workflow specification connection	Workflow specification model
Workflow specification connection property	Workflow specification model
Workflow specification connection type	Workflow specification model
Workflow specification connection type property	Workflow specification model
Workflow specification node	Workflow specification model
Workflow specification node property	Workflow specification model
Workflow specification node type	Workflow specification model
Workflow specification node type property	Workflow specification model

15 Compliance

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

- a) The use of the terminology defined in this standard
- b) The object models supported (resource relationship network, work definition, work schedule, work performance, work capability, job list, and work alert)
- c) The use of objects listed in Table 35 that are supported
- d) The use of the attributes for each supported object
- e) The relationships between the supported objects
- f) A statement of the total compliance concerning definitions, objects, attributes, and relationships or, in case of partial compliance, a statement identifying explicitly the areas of noncompliance.

Annex A (Informative) Bibliography

MIMOSA OSA-EAI CCOM V3.2 – www.mimosa.org

BPMN specifications are maintained by Object Management Group (OMG) at <http://www.omg.org/spec/BPMN>. The current version is 2.0.

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Annex B (Informative) Questions and answers about object use

B.1 How are dependencies in the work schedule and work response handled?

Question:

How are dependencies in the work schedule and work response handled?

Answer:

There are different types of dependencies (resource availability, customer priority, process dependency, and other).

Real applications need to model different types of dependencies between work requests.

For example, an MRP/ERP at Level 4 can produce separate requests for subassemblies or a single request for the final assembly of a given finished product and for the manufacturing of the intermediate materials that are the subassemblies to be assembled. Of course, there is a work process dependency relationship and final assembly shall start after all subassemblies have been manufactured. This is handled in an implementation where a production or work request states the start time and/or end time and then the associated segment requests specify the earliest start time, latest end time and duration for each segment. The algorithm for the actual dispatching of work can be done at Level 4 or Level 3, but represented in the production schedule or work schedule request.

B.2 What are examples of resource relationships?

Question:

What are some examples of resource relationships and how are they important?

Answer:

Resource relationships model resources that have some form of dependency among the resources.

In the examples below the resource relationship may be annotated with properties that are relevant to the environment. Properties such as optimum paths, rework paths, and selection criteria for scheduling and planning applications could be included.

The resource relationships may be an input to an application indicating configuration properties of the system or an output representing the result of a calculation such as an optimization process that has generated a resource relationship model to indicate its output.

The following example describes three different resource relationships using the equipment resources shown in Figure 20.

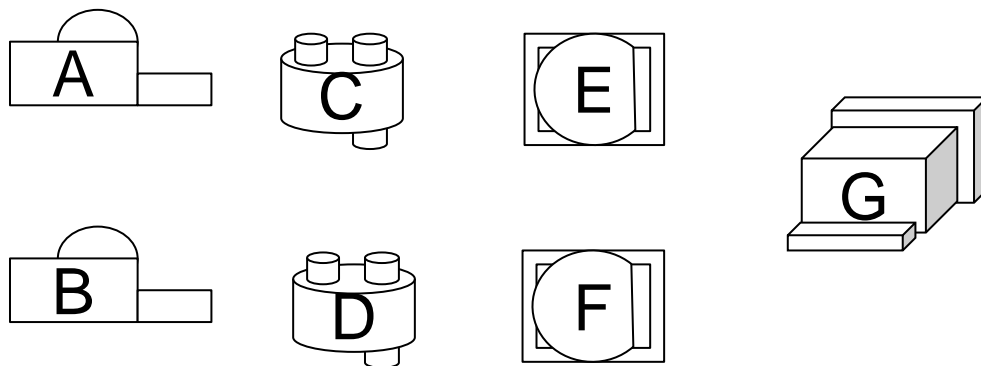


Figure 18 — Equipment resources

The first relationship is a material flow routing network as shown in Figure 21.

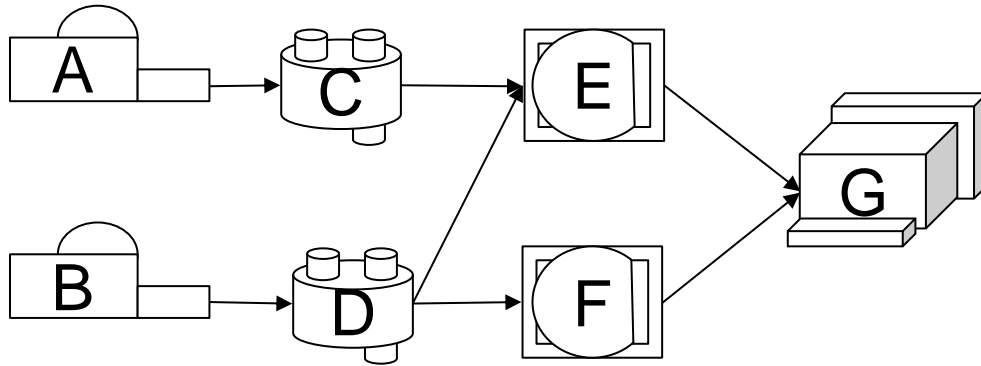


Figure 19 — Routing relationship network

The routing relationship network would be modelled as a set of resource network connections:

<Resource Network Connection AC> <From Resource Reference to A> <To Resource Reference to C>
 <Resource Network Connection CE> <From Resource Reference to C> <To Resource Reference to E>
 <Resource Network Connection EG> <From Resource Reference to E> <To Resource Reference to G>
 <Resource Network Connection BD> <From Resource Reference to B> <To Resource Reference to D>
 <Resource Network Connection DE> <From Resource Reference to D> <To Resource Reference to E>
 <Resource Network Connection DF> <From Resource Reference to D> <To Resource Reference to F>
 <Resource Network Connection FG> <From Resource Reference to F> <To Resource Reference to G>

A detailed scheduling package would use the routing network to determine which paths through the equipment should be used for each production run.

The next relationship, shown in Figure 22, with the same equipment illustrates, a gas line relationship, showing which equipment is connected to a gas main. This relationship could be used by a maintenance scheduling activity to determine which equipment must be shut down when maintenance is performed on the gas main network.

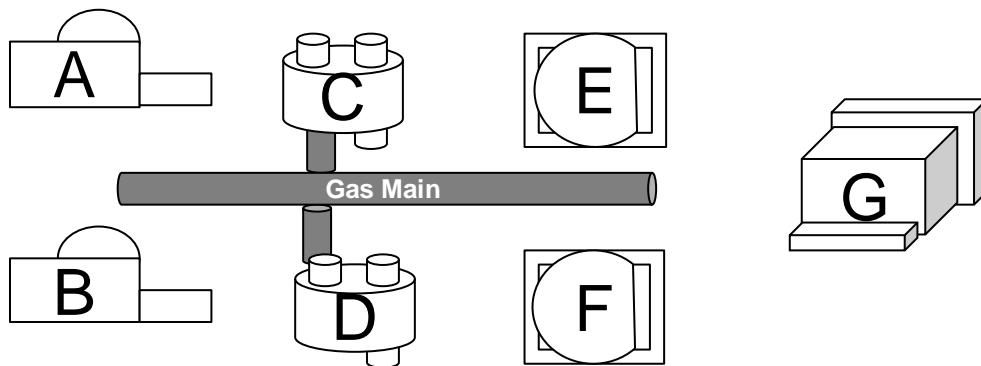


Figure 20 — Gas main relationship network

The gas main relationship network would be modelled as a set of resource network connections:

<Resource Network Connection GM1> <From Resource Reference to GAS_MAIN> <To Resource Reference to C>
 <Resource Network Connection GM2> <From Resource Reference to GAS_MAIN> <To Resource Reference to D>

A resource relationship network across resource types is shown in Figure 23. This relationship defines which equipment can be used for material definition X.

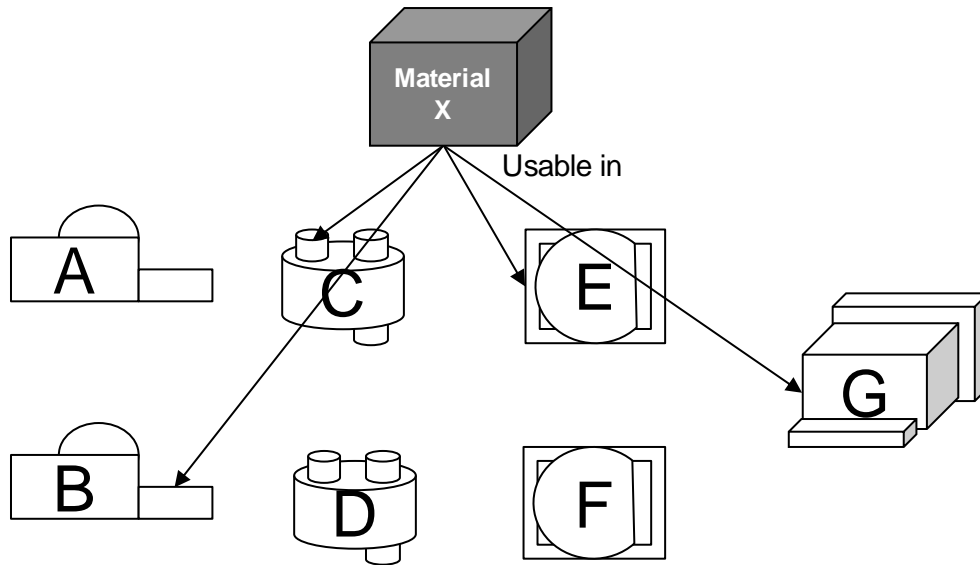


Figure 21 — “Usable in” relationship network

The “usable in” relationship network would be modelled as a set of resource network connections, with each relationship containing selection criteria relevant to the selection algorithm:

- <Resource Network Connection X1> <From Resource Reference to Material X> <To Resource Reference to B>
- <Resource Network Connection X2> <From Resource Reference to Material X> <To Resource Reference to C>
- <Resource Network Connection X3> <From Resource Reference to Material X> <To Resource Reference to E>
- <Resource Network Connection X4> <From Resource Reference to Material X> <To Resource Reference to G>

This relationship would be used by a detailed scheduler to determine which resources may be used for production of material X.

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Annex C

(Informative)

Related standards

Level 3 to Level 2 interfaces are defined in the IEC 62541 OPC unified architecture specification standards.

Standards for recipes are defined in the IEC 61512 batch control standards.

As shown in Figure 22, there is a relationship between the information models in Part 2, the models in Part 4, and the models in ISA-88 / IEC 61512. The Part 2 models are used to exchange information based on the Level 4 business view of operations, using process segments as the method to define segments of operation as viewed by the business processes. Models such as operations definition and operations schedule support business view by defining the allocation of resources and scheduling activities to the site.

Part 4 models are used to exchange information for Level 3 execution. Models such as work definition may reference the operations definition exchanged with Level 4, but they contain the details needed for actual execution of Level 3 activities. Additionally, work master and work directive are types of work definitions that provide the details needed for work execution

A single operations definition may relate to one or more work masters. The work masters describe how to perform the work, using the resources identified in the operations definition. A work directive is created from a work master for a specific job order. If the step in a work directive defines a batch process (or work accomplished through a recipe), then the step in a work master may reference a master recipe (ISA-88) and a step in the work directive may reference a control recipe (ISA-88).

An operations schedule (Part 2) (*defining the resource allocation*) is used to create a work schedule (Part 4) (*defining the physical routing and sequencing*) in a detailed production scheduling activity (Part 3). An operations dispatching activity (Part 3) uses the job list (Part 4) view of the work schedule. If there are batch processes in the job list, then the created batches are maintained in a batch list (ISA-88).

Information on the execution of a batch can be maintained in a batch production record. This information could then be combined with other information in a work production record (*not defined in Part 4, but defined in the related B2MML (www.wbf.org) standards*). This information can then be used to create work performance information (Part 4) (*defining the resource usage for the physical routing*), which in turn can be used to create production performance information (Part 2) (*defining the resource usage as viewed by business activities*).

ANSI/ISA-88.00.03 / IEC 61512-3 define an object model for general and site recipes, which define a research and development view of a product, independent of any specific equipment. There is no direct equivalent for these in the ISA-95 models. However the ISA-88 models may be used to help define Level 4 operations definitions and/or Level 3 work masters by relating process stages (ISA-88) and process operations (ISA-88) to process segments and to the routing defined in operations definitions and work masters.

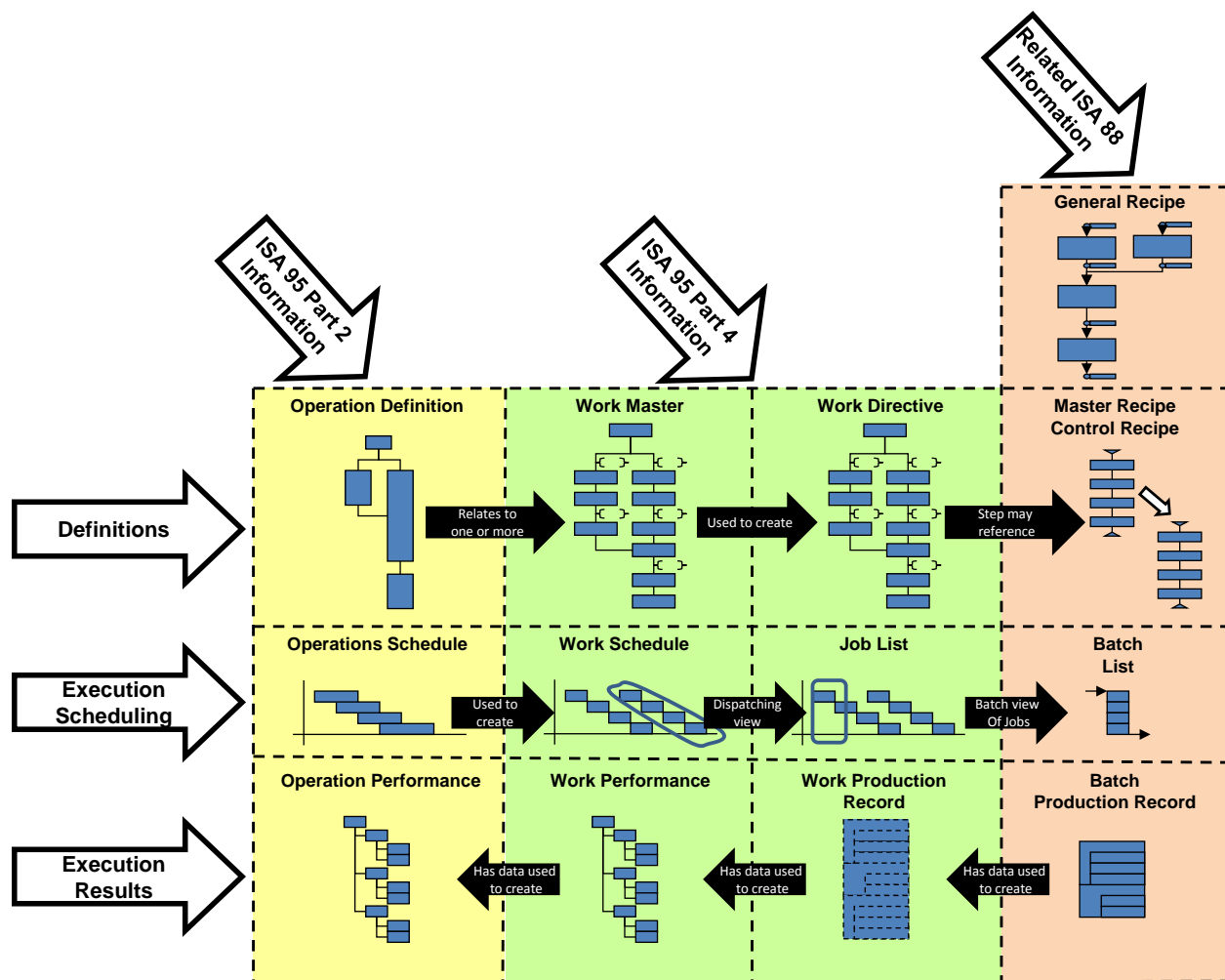








Figure 22 — Relationship to Part 2 and ISA-88 standards

Annex D (Informative) Representing a workflow specification in BPMN

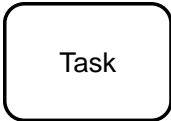

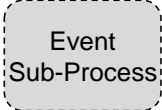






This section defines a possible mapping of BPMN 2.0 – Business Process Model and Notation to a Workflow Specification.

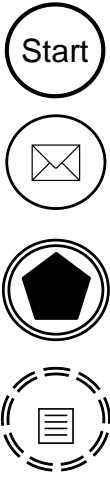




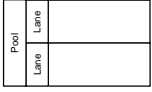
BPMN defines multiple different elements in a collaboration diagram; these include activities, gateways, events, data, choreographies, and conversations.

In general the following elements would be represented as workflow specification connection types:

Name	Symbol	Description
Sequence flow		Defines the execution order of activities
Default flow		Defines the default branch chosen if all other conditions evaluate to false.
Conditional flow		Defines a branch with a condition assigned that defines whether or not the flow is used.
Message flow		Symbolizes information flow across organizational boundaries.
Conversation link		Connects communications and participants.
Forked conversation link		Connects communications and multiple participants.

The following workflow specification node types could be defined to match elements in BPMN. The following is a partial list of all activities, gateways, events, data, choreographies, and conversations types.

Name	Symbol	Description
Task		Represents a unit of work, the job to be performed. May be annotated with different: <ul style="list-style-type: none"> activity markers: sub process marker, loop marker, parallel MI marker, sequential MI marker, ad hoc marker, compensation marker. task types: send task, receive task, user task, manual task, business rule task, service task, script task.
Transaction		A set of activities that logically belong together.
Event sub-process		A task that is activated when the start event is triggered.
Call activity		A wrapper for a globally defined sub-process or task
Exclusive gateway		When splitting it routes the sequence flow to exactly one of the outgoing branches. When merging, it waits for one incoming branch to complete before triggering the outgoing flow.
Event-based gateway		Is always followed by catching events or receive tasks.
Parallel gateway		When used to split the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches it waits for all incoming branches to complete.
Inclusive gateway		When splitting one or more branches are activated,
Complex gateway		Complex merging and branching behavior that is not captured in other gateways

Event		<p>There are multiple types of events and each event may be defined for different position in the execution sequence. Special indications:</p> <ul style="list-style-type: none"> message, timer, escalation, conditional, link, error, cancel, compensation, signal, multiple, parallel multiple, terminate <p>Sequence indications:</p> <ul style="list-style-type: none"> top-level, start – event sub-process interrupting, start – event sub-process non-interrupting, intermediate catching, intermediate boundary interrupting, intermediate boundary non-interrupting, intermediate throwing, end <p>Each event subtype would be represented as a different symbol on a BPMN diagram, as shown with figures to the left.</p>
Input		An external input for the entire process
Output		A variable available as the result of the entire process
Data store		A place where the process can read and/or write data.
Pool (swimlane)		Represents responsibilities for activities in a process.
Lane (swimlane)		Represents responsibilities for activities in a process.

The following example is used to illustrate the mapping to a workflow specification. The following abbreviations are used: workflow specification (WFS), workflow specification node (WSN), workflow specification node property (WSNP), workflow specification connection (WSC), and workflow specification connection property (WSCP).

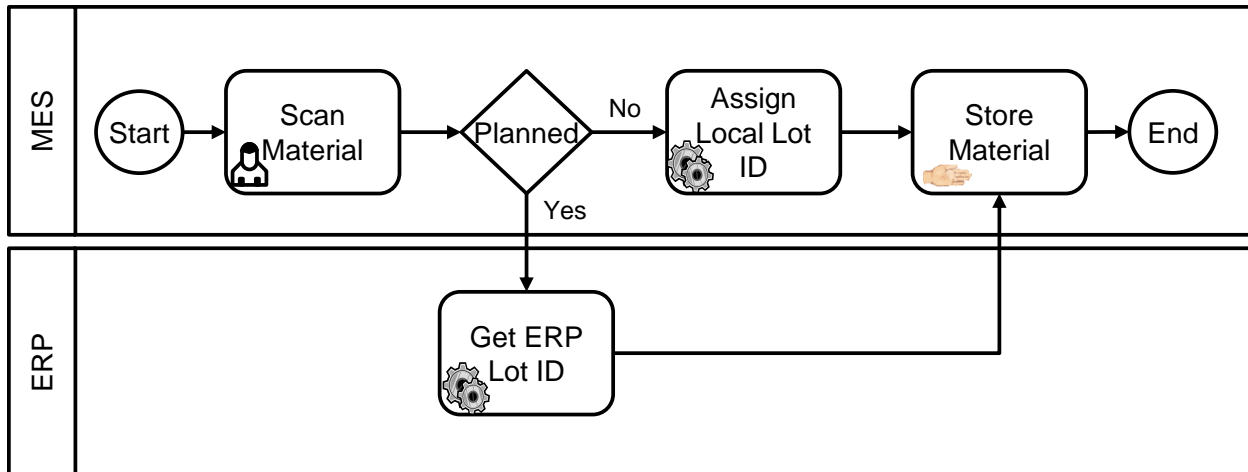


Figure 23 — Example of a workflow specification in BPMN notation

Figure 24 illustrates the aggregation hierarchy of the workflow specification model.

```

WS: ID=EXAMPLE
+---- WSN: ID=MES, Type=LANE
+---- WSN: ID=Start, Type=EVENT START
+---- WSN: ID=Scan Material, Type=TASK
+---- WSNP: Task Type=MANUAL
+---- WSN: ID=Planned, Type=EXCLUSIVE GATEWAY
+---- WSN: ID= Assign Local Lot ID, Type=TASK
+---- WSNP: Task Type=SERVICE
+---- WSN: ID= Store Material, Type=TASK
+---- WSNP: Task Type=USER TASK
+---- WSN: ID= End, Type=EVENT END
+---- WSC: From=Start, To=Scan Material
+---- WSC: From= Scan Material, To=Planned
+---- WSC: From=Planned, To=Get ERP Lot ID
+---- WSCP: Condition=YES
+---- WSC: From=Planned, To=Assign Local Lot ID
+---- WSCP: Condition=NO
+---- WSC: From= Assign Local Lot ID, To=End
+---- WSN: ID=ERP, Type=LANE
+---- WSN ID=Get ERP Lot ID, Type=TASK
+---- WSNP: Task Type=SERVICE
+---- WSC: From= Get ERP Lot ID, To=Assign Local Lot ID

```

Figure 24 — Example workflow process in the workflow specification model

Annex E (Informative) Representing a workflow specification in flowchart notation

This section defines a possible mapping of flowcharts to a workflow specification.

The following workflow specification node types could be defined to match elements in a flow chart:

process, decision, data, document, predefined process, stored data, internal storage, sequential data, direct data, manual input, card, paper tape, display, manual operation, preparation, parallel mode, loop limit, terminator

The following workflow specification connection type could be defined to match the links between flowchart elements:

control transfer

The following example is used to illustrate the mapping to a workflow specification. The following abbreviations are used: workflow specification (WPN), workflow specification node (WSN), workflow specification node property (WSNP), workflow specification connection (WSC), and workflow specification connection property (WSCP).

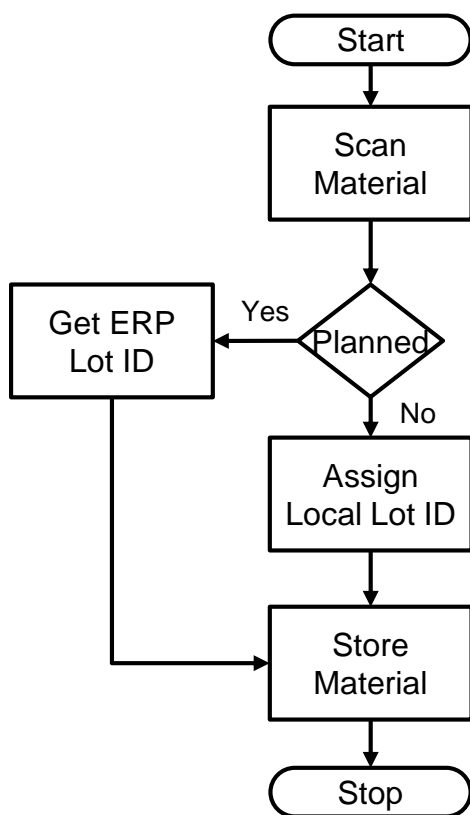


Figure 25 — Example of a workflow specification in flowchart notation

Figure 26 illustrates the aggregation hierarchy of the workflow specification model.

```

WPN: ID=EXAMPLE
+--- WSN: ID=MES, Type=LANE
+---- WSN: ID=Start, Type=START
+---- WSN: ID=Scan Material, Type=PROCESS
+---- WSN: ID=Planned, Type=DECISION
+---- WSN: ID= Assign Local Lot ID, Type= PROCESS
+---- WSN: ID= Store Material, Type= PROCESS
+---- WSN: ID= Stop, Type=TERMINATOR
+---- WSC: From=Start, To=Scan Material
+---- WSC: From= Scan Material, To=Planned
+---- WSC: From=Planned, To=Get ERP Lot ID
+---- WSCP: Condition=YES
+---- WSC: From=Planned, To=Assign Local Lot ID
+---- WSCP: Condition=NO
+---- WSC: From= Assign Local Lot ID, To=End
+--- WSN: ID=ERP, Type=LANE
+---- WSN ID=Get ERP Lot ID, Type= PROCESS
+---- WSC: From= Get ERP Lot ID, To=Assign Local Lot ID

```

Figure 26 — Example workflow process in the workflow specification model

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