‹AutomationML/›

The Glue for Seamless Automation Engineering

Application Recommendation Provisioning for MES and ERP – Support for IEC 62264 and B2MML

Author: Bernhard Wally
         b.wally@rat-fte.at
         Austrian Council for Research and Technology Development

Table of Content

List of Figures

List of Tables

List of Code Listings

Preamble I   Provided Libraries

I.1   Role Class Libraries

Role Class Library Name	Version	Comment
AutomationMLB2MMLRoleClassLib	2.0.0	B2MML Role Class Library
AutomationMLIEC62264RoleClassLib	2.0.0	IEC 62264 Role Class Library

I.2   Interface Class Libraries

Interface Class Library Name	Version	Comment
AutomationMLIEC62264InterfaceClassLib	2.0.0	IEC 62264 Interface Class Library

I.3   Attribute Type Libraries

Attribute Type Library Name	Version	Comment
AutomationMLIEC62264AttributeTypeLib	2.0.0	IEC 62264 Attribute Type Library

Preamble II   Referenced Libraries

II.1   Role Class Libraries

Role Class Library Name	Version	Comment
AutomationMLBaseRoleClassLib	2.2.5	AML Base Role Class Library
AutomationMLExtendedRoleClassLib	2.7.0	AML Extended Role Class Library (non-normative)
AutomationMLBMIRoleClassLib	1.1.0	AML Batch Manufacturing Industry Role Class Library
AutomationMLCMIRoleClassLib	1.1.0	AML Continuous Manufacturing Industry Role Class Library
AutomationMLDMIRoleClassLib	2.4.0	AML Discrete Manufacturing Industry Role Class Library
AutomationMLCSRoleClassLib	2.3.0	AML Control Industry Role Class Library

II.2   Interface Class Libraries

Interface Class Library Name	Version	Comment
AutomationMLInterfaceClassLib	2.2.5	Standard AML Interface Class Library

II.3   Attribute Type Libraries

Attribute Type Library Name	Version	Comment
AutomationMLBaseAttributeTypeLib	1.0.0	Standard AML Attribute Type Library

Preamble III Referenced Documents

Document-ID	Version	Comment
WP-Part1	2.1.0	AML Whitepaper Part 1: Architecture and General Requirements
WP-Part2	2.0.0	AML Whitepaper Part 2: Role Class Libraries

Preamble IV Document History

Version	Comment
1.0.0	Initial Version
1.1.0	PersonnelClass and Person inherit from Resource
1.1.1	Added a discriminator attribute "role" to DependencyConnector interface class
2.0.0	Switched to AutomationML Edition 2 (CAEX 3.0). Main differences: (i) external data references are now part of the base libraries instead of externalized in a best practice recommendation. (ii) attribute type libraries are used for user defined properties, as well as for the required attributes in external data references.

1 Introduction

AutomationML[1] (AML) is a standard published by the International Electronic Commission[2] (IEC) for the exchange of information between automation engineering tools, released as IEC 62714. It is based on the *Computer Aided Engineering Exchange* (CAEX) standard (IEC 62424), which defines a neutral data format for the storage of object hierarchies and object relations, encoded in *Extendable Markup Language* (XML). Its original application scenario is the description of the static structure of a plant's shop floor. AML introduces a distributed document architecture where different documents can be linked together from a central AML document (cf. Figure 1).

The focus of AML so far has been in the description of the shop floor, i.e. the definition of machines, their terminals and communication links, and how they are all wired together. Geometric and kinematic information can be linked to AML objects through the *Collaborative Design Activity*[3] (COLLADA) file format, which is also XML based. Logic descriptions for the programming of automated machines can be referenced through documents stored in the *PLCopen[4] XML* data format.
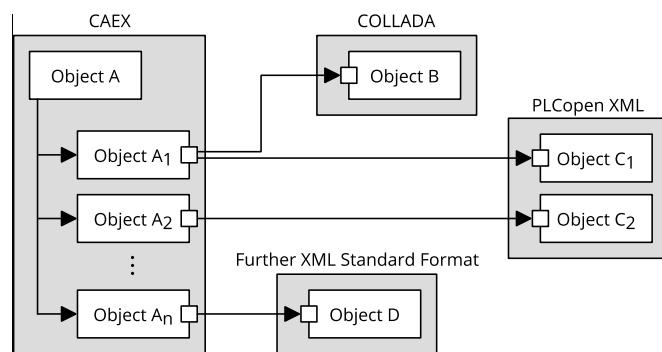
Figure 1: Overview of the engineering data exchange format AML.

1.1 Provisioning for ERP and MES

In a fully integrated system, business and manufacturing functions are aligned in order to foster an efficient data flow. For the data exchange between *Enterprise Resource Planning* (ERP) systems and *Manufacturing Execution Systems* (MES) a data standard has been specified in the IEC 62264 series, based on a standard that has been standardized by the American National Standards Institute[5] (ANSI) and the International Society of Automation[6] (ISA): ANSI/ISA-95. A complete XML implementation of IEC 62264 has been published as the *Business To Manufacturing Markup Language* (B2MML) by the *Manufacturing Enterprise Solutions Association* (MESA) International[7].

After IEC 62264 enables the linking of the business layer (ERP and supply chain management) to the manufacturing layer, linking objects from AML to elements of IEC 62264 further fosters the integration of manufacturing layers.

---

[1] https://www.automationml.org/
[2] http://www.iec.ch/
[3] https://www.khronos.org/collada/
[4] http://www.plcopen.org/
[5] https://www.ansi.org/
[6] https://www.isa.org/
[7] http://www.mesa.org/

1.2 IEC 62264

IEC 62264 comprises six parts that deal with various aspects of enterprise control system integration. In cases where references to these documents are written without revision information (year of publication), the following default revisions apply:

- IEC 62264-1:2013 Models and Terminology

- IEC 62264-2:2013 Objects and Attributes for Enterprise-Control System Integration

- IEC 62264-3:2016 Activity Models of Manufacturing Operations Management

- IEC 62264-4:2015 Object Model Attributes for Manufacturing Operations Management Integration

- IEC 62264-5:2016 Business to Manufacturing Transactions

- IEC 62264-6:2020 Messaging Service Model

AutomationML as an object-oriented data format mainly overlaps or is related to IEC 62264-2 and IEC 62264-4, where core objects and relationships that are relevant in the context of shop floor modeling and data exchange between office floor and shop floor are depicted. Specifically, IEC 62264-2 defines five types of resources that are briefly described in Clauses 1.2.1 to 1.2.5 (an exhaustive mapping of IEC 62264-2 concepts to AML is given in Clause 3). Together, they form the fundament for further modeling steps, such as operations planning, operations performance, etc.

NOTE: This document describes the integration of part 2 if IEC 62264, IEC 62264-2, with AML. Integration of other parts (specifically, with IEC 62264-4) will be realized in future versions of this document.

1.2.1 Personnel

Personnel comprises the actors that are required to operate manufacturing processes. AML is not focused on the definition of human resources, however if required, they could be modeled in AML as well.

1.2.2 Equipment

Equipment represents the equipment of an organization in form of a role-based model. One example is the business structure of an organization with regards to physical, geographical or logical features, such as the enterprise and its sites, areas, process cells, production units, production lines, storage zones, units, work cells, and storage units (cf. Figure 2). More specific examples include welders, titration testers, lift trucks, reactors, etc. Equipment may define a hierarchy.

NOTE: Concerning the AutomationMLBaseRoleClassLib, equipment corresponds to the "Resource" or "ResourceStructure" role classes.
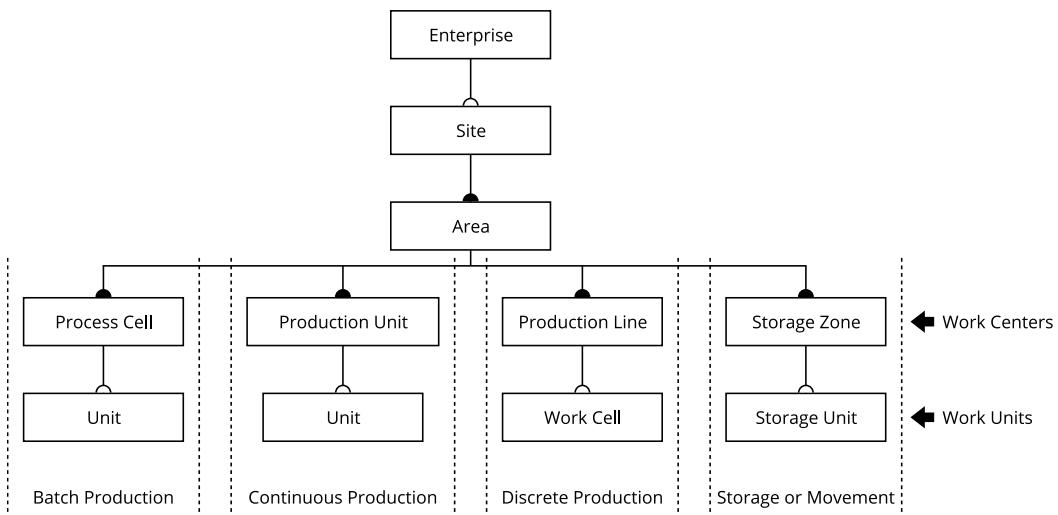
Figure 2: Typical expanded equipment hierarchy (from [IEC 62264-1], graphically adapted).

1.2.3 Physical Asset

Physical assets represent the physical pieces of equipment, i.e. while equipment defines the roles for certain items, a physical asset is the real physical item that implements that role. Physical assets have an impact on the ERP layer, as they are usually of value and need to be tracked financially. Machines for instance have a unique serial number, as such the serial number of a machine resembles a valid value for a physical asset's ID. A dedicated equipment asset mapping represents the relationship between a physical asset and an equipment. It records the time frame in which a physical asset was associated with an equipment.

1.2.4 Material

Material represents raw, finished, and intermediate materials, as well as consumables. A uniquely identified amount of material is referred to as material lot.

NOTE: Concerning the AutomationMLBaseRoleClassLib, material corresponds to the "Product" or "ProductStructure" role classes.

1.2.5 Process Segment

Process segments resemble the smallest elements of manufacturing activities that are visible to business processes. Process segments describe a hierarchical model in which multiple levels of abstraction may be defined. Process segments are also a logical grouping of personnel, equipment, physical asset, and material required for a specific manufacturing operation.

NOTE: Concerning the AutomationMLBaseRoleClassLib, process segment corresponds to the "Process" or "ProcessStructure" role classes.

1.3 Structure of this Document

The remainder of this document is structured as follows:

- Clause 2 lists (or refers to documents that in turn list) terms, definitions and abbreviations in use in this document.

- Clause 3 describes a mapping of IEC 62264-2 elements to AML modeling elements, i.e., it is a mapping of the IEC 62264-2 and CAEX metamodels.

- Clause 4 depicts the relation of IEC 62264-2 elements to concepts already declared in the AML environment.

- Clause 5 is a set of modeling rules for the *modeling of IEC 62264-2 elements within AML* documents.

- Clause 6 defines the mechanism for *referencing IEC 62264-2 information that resides outside AML* documents but can be referred from AML documents.

- Clause 7 describes potential conflicts between IEC 62264-2, AML and OPC UA; and how to resolve them.

- Appendix A lists the IEC 62264 interface class library defined in this document.

- Appendix B lists the IEC 62264 role class library defined in this document.

- Appendix C lists the B2MML role class library defined in this document.

- Appendix E provides examples for the referencing of external B2MML documents from AML documents with different levels of complexity.

2　Terms, Definitions and Abbreviations

2.1　Terms and Definitions

For the purpose of this document, the terms and definitions of IEC 62714-1:2018 and of IEC 62714-2:2015 apply.

2.2　Abbreviations

For the purpose of this document, the abbreviations of IEC 62714-1:2018 and of IEC 62714-2:2015 apply.

2.3　Conformity

In the scope of AML, a B2MML document shall conform to the specification of B2MML version 6.0 (V0600) released in March 2013.

3 Mapping of IEC 62264-2 to AutomationML

IEC 62264-2 defines (i) basic resources that depict the static definitions of an enterprise with regards to its production facilities, such as personnel and material (cf. Clause 3.1) and (ii) operations management information that resembles operational data such as schedules and logs (cf. Clause 3.2).

The following Clauses each (i) describes a sub model of IEC 62264-2, (ii) shows its Unified Modeling Language[8] (UML) class diagram, and (iii) provides a table comprising a mapping of each IEC 62264-2 concept to one or more corresponding AutomationML element(s). The tables follow the template depicted in Table 1: the first column "IEC 62264-2" identifies the IEC 62264-2 concept (usually a UML class name), the second column "AutomationML" shows the possible AutomationML elements the concept might be realized with, and the third column gives a brief description of the concept in question, usually taken from [IEC 62264-2].

IEC 62264-2	AutomationML	Comment
«IEC 62264-2 Concept» e.g. Person.	«AutomationML Concept» e.g. InternalElement. *NOTE: Multiple AML elements are specified in case several AML concepts fit the given IEC 62264-2 concept or are required (One-to-Many Mapping).*	«A brief description of the concept in question, usually taken from [IEC 62264-2].»

Table 1: Template for the mapping of IEC 62264-2 concepts to AutomationML elements.

3.1 IEC 62264-2 Common Object Models

3.1.1 Hierarchy Scope

One often used concept in IEC 62264-2 is that of levels and scopes in a hierarchy. To account for that a simple helper class "HierarchyScope" has been defined in IEC 62264-2 (cf. Figure 3) that can be used to define an equipment hierarchy. A hierarchy scope refers to a piece of equipment and defines an equipment level for that equipment based on the principles defined in Clause 1.2.2. A mapping of the hierarchy scope model to AML is given in Table 2.
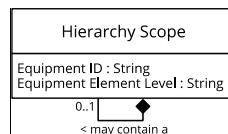
Figure 3: Hierarchy scope model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Hierarchy Scope	InternalElement	Identifies where the exchanged information fits within the role based equipment hierarchy. It defines the scope of the exchanged information, such as a site or area for which the information is relevant.

Table 2: Mapping of the IEC 62264-2 hierarchy scope model to AML.

---

[8] http://www.omg.org/spec/UML/

3.1.2   Personnel

The IEC 62264-2 personnel model (cf. Figure 4) enables the modeling of classes of personnel, specific personnel, and qualifications of personnel [IEC 62264-2]. Personnel classes and individual persons may define properties. A mapping of the personnel model to AML is given in Table 3. Personnel entities have not been explicitly considered in IEC 62714 parts 1 to 4, because of its focus on the physical setup of manufacturing systems. While the modeling of specific persons might be out of scope for many AML models, the specification of personnel classes might be useful for a more detailed view on the manufacturing process.

Persons are modeled as internal elements, while personnel classes are modeled as role classes. With this setup a person can implement multiple personnel classes and a personnel class can be implemented by multiple person elements, which corresponds to the IEC 62264-2 model. A personnel class can be instantiated once (singleton pattern) as an internal element, in order to make it available in an instance hierarchy for e.g., linking.

A person must directly or indirectly refer to the generic "Person" role class defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib), while a person class must inherit from the "PersonClass" role class. The singleton instance of a personnel class (if existing) must not refer to the "Person" role class, but refer to the personnel class role class it represents. The singleton instance is used e.g., when referencing a personnel class from a process segment.
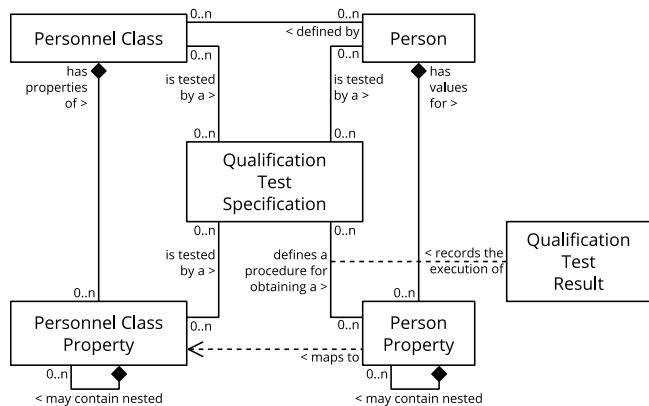
Figure 4: Personnel model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Personnel Class	RoleClass (mandatory) - and - InternalElement (optional)	Representation of a grouping of persons with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability, and performance.
Personnel Class Property	Attribute	Each personnel class shall have zero or more recognized properties.
Person	InternalElement	Representation of a specifically identified individual. A person may be a member of zero or more personnel classes.
Person Property	Attribute	Each person shall have zero or more person properties. These specify the current property values of the person for the associated personnel class property.
Qualification Test Specification	InternalElement	Representation of a qualification test. Can be associated with a personnel class, personnel class property, person, or person property.
Qualification Test Result	InternalElement	Results from a qualification test for a specific person.

Table 3: Mapping of the IEC 62264-2 personnel model to AML.

3.1.3   Equipment

IEC 62264-2 role based equipment information (cf. Figure 5) resembles information about classes of equipment, specific equipment, and equipment capability tests [IEC 62264-2]. Equipment classes and specific equipment may define properties. A mapping of the equipment model to AML is given in Table 4.

The mapping is realized following the arguments of the personnel model, i.e., a person is implemented as an internal element in AML and an equipement class as a role class. Similar to the personnel model, an equipment class may be instantiated once as an internal element.

An equipment must directly or indirectly refer to the generic "Equipment" role class defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib), while an equipment class must inherit from the "EquipmentClass" role class. The singleton instance of an equipment class (if existing) must not refer to the "Equipment" role class, but refer to the equipment class role class it represents. The singleton instance is used e.g., when referencing an equipment class from a process segment.
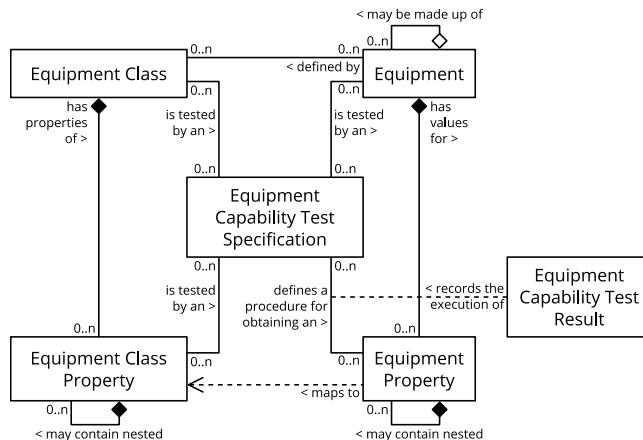
Figure 5: Equipment model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Equipment Class	RoleClass (mandatory) - and - InternalElement (optional)	Representation of a grouping of equipment with similar characteristics.
Equipment Class Property	Attribute	Each equipment class may have zero or more recognized properties.
Equipment	InternalElement	Representation of the elements of the equipment hierarchy model.
Equipment Property	Attribute	An equipment shall have zero or more equipment properties. These may include a unit of measure.
Equipment Capability Test Specification	InternalElement	Representation of a capability test. May be associated with an equipment class, equipment class property, equipment or equipment property.
Equipment Capability Test Result	InternalElement	Results from an equipment capability test for a specific piece of equipment.

Table 4: Mapping of the IEC 62264-2 equipment model to AML.

3.1.4   Physical Asset

The IEC 62264-2 physical asset model (cf. Figures 6 and 7) contains information about physical pieces of equipment [IEC 62264-2]. Physical asset classes and physical assets may define properties. A mapping of the physical asset model to AML is given in Tables 5 and 6.

The physical asset model has different cardinalities between the object element (physical asset) and the type element (physical asset class) than the personnel and the equipment models. Still, similar to the other models, a physical asset is instantiated as an internal element, but this time with a required reference to a system unit class representing a physical asset class. Further, a physical asset class is modeled as a system unit class that can be instantiated by any number of physical assets (1:n mapping).

A physical asset must directly or indirectly refer to the generic "PhysicalAsset" role class defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib), while a physical asset class must inherit from the "PhysicalAssetClass" role class. The singleton instance of a physical asset class (if existing) must not refer to the "PhysicalAsset" role class, but refer to the physical asset class role class it represents. The singleton instance is used e.g., when referencing a physical asset class from a process segment.
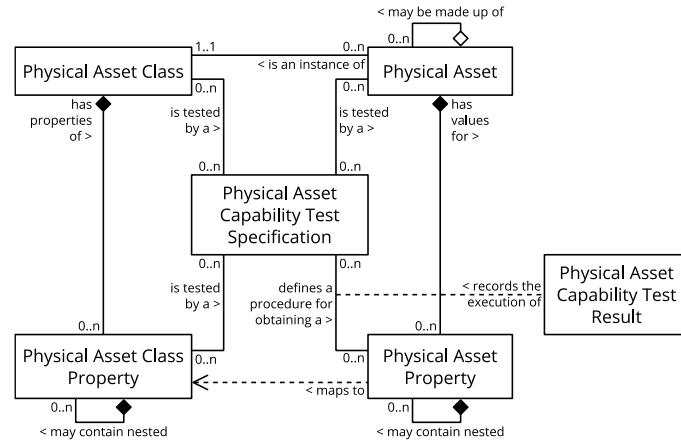
Figure 6: Physical asset model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Physical Asset Class	SystemUnitClass (mandatory) - and - InternalElement (optional)	A representation of a grouping of physical assets with similar characteristics for purposes of repair and replacement.
Physical Asset Class Property	Attribute	Each physical asset class may have zero or more recognized properties.
Physical Asset	InternalElement	A physical piece of equipment shall be presented as a physical asset. Any physical asset shall be a member of one physical asset class.
Physical Asset Property	Attribute	A physical asset shall have zero or more physical asset properties.
Physical Asset Capability Test Specification	InternalElement	Representation of a capability test. May be associated with a physical asset property.
Physical Asset Capability Test Result	InternalElement	Results from a qualification test for a specific physical asset.

Table 5: Mapping of the IEC 62264-2 physical asset model to AML.
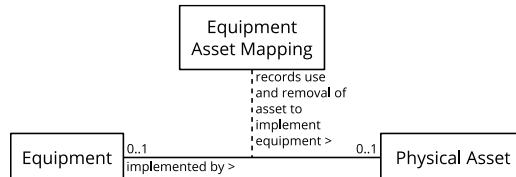
Figure 7: Relationship between equipment information and physical asset information (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Equipment Asset Mapping	InternalElement	Relationship between a physical asset and an equipment. It records the period when one equipment entity and one physical asset entity were associated.

Table 6: Mapping of the IEC 62264-2 relationship between equipment information and physical asset information.

3.1.5　Material

The IEC 62264-2 material model (cf. Figure 8) defines information about classes of material, material definitions, and actual materials [IEC 62264-2]. Material classes, material definitions, and actual material may define properties. A mapping of the material model to AML is given in Table 7.

Material classes are implemented in AML as role classes that can be implemented by multiple material definitions that in turn are implemented as system unit classes. Material lots and sublots are implemented as internal elements with the sublots modeled as child elements of their parent lots or sublots.

A material lot or sublot must directly or indirectly refer to the generic "MateriaLot" or "MaterialSublot" role class defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib), while a material definition must refer to the "MaterialDefinition" role class and a material class must inherit from the "MaterialClass" role class. The singleton instance of a material class or material definition (if existing) must not refer to the "MaterialLot" or "MaterialSublot" role class, but refer to the material class role class or material definition system unit class it represents. The singleton instance is used e.g., when referencing a material class or material definition from a process segment.
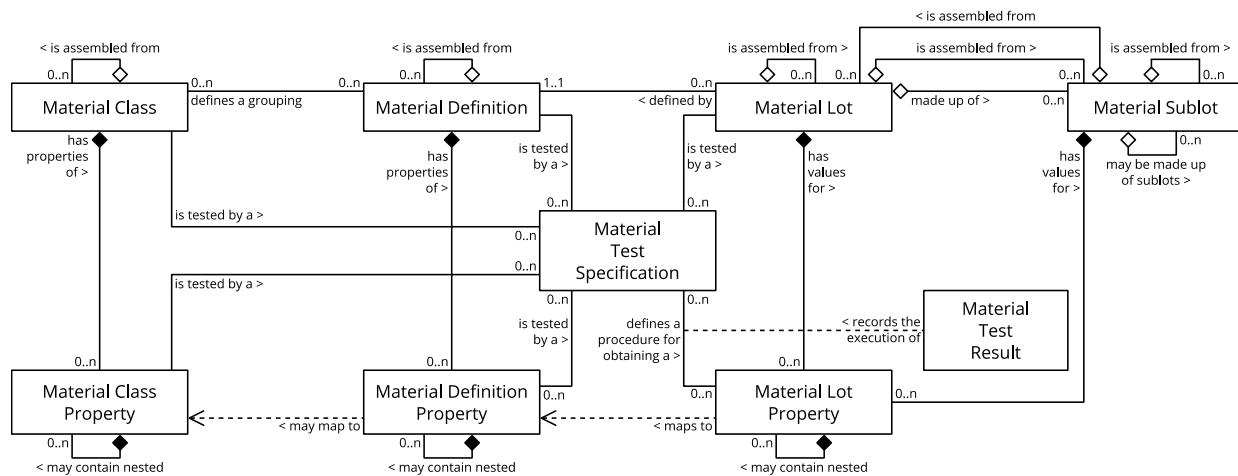
Figure 8: Material model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Material Class	RoleClass (mandatory) - and - InternalElement (optional)	Representation of groupings of material definitions for a definite purpose such as manufacturing operations definition, scheduling, capability and performance.
Material Class Property	Attribute	A material class may define zero or more material class properties.
Material Definition	SystemUnitClass (mandatory) - and - InternalElement (optional)	Representation of goods with similar name characteristics for the purpose of manufacturing definition, scheduling, capability and performance.
Material Definition Property	Attribute	A material definition may define zero or more material definition properties.
Material Lot	InternalElement	Uniquely identified specific amount of material, either countable or weighable. A material lot describes the planned or actual total quantity or amount of material available, its current state, and its specific property values.
Material Lot Property	Attribute	Each material can have unique values for zero or more material lot properties, such as a specific pH value for the specific material lot, or a specific density for the material lot.
Material Sublot	InternalElement	Separately identifiable quantity of the same material lot.
Material Test Specification	InternalElement	Representation of a material test. Shall be associated with one or more material definition properties.
Material Test Result	InternalElement	Results from the execution of a quality assurance test. Records the results from a material test for a specific material lot or material sublot.

Table 7: Mapping of the IEC 62264-2 material model to AML.

3.1.6   Process Segment

IEC 62264-2 process segments are the smallest elements of manufacturing activities that are visible to business processes. The process segment model is a hierarchical model that reflects a logical grouping of personnel, equipment, physical assets, and material (cf. Figure 9) [IEC 62264-2]. A mapping of the process segment model to AML is given in Table 8.

A process segment is modeled as an internal element with its diverse specifications modeled as children internal elements. Process segments must refer to role class "ProcessSegment" that is defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib). The same (but with their corresponding classes) applies to the other internal elements listed in this mapping.
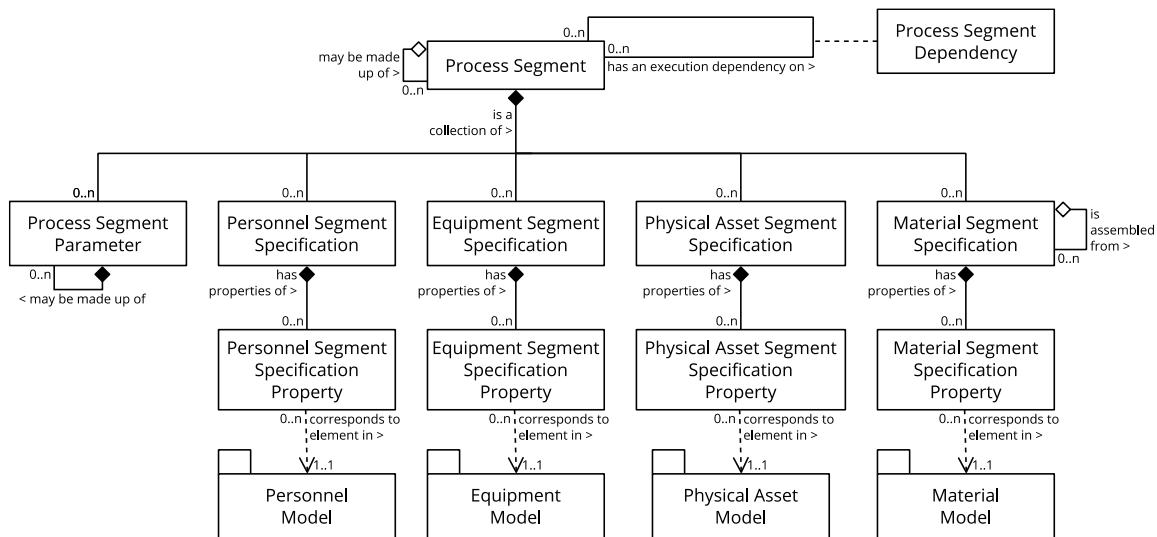
Figure 9: Process segment model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Process Segment	InternalElement	Lists the classes of personnel, equipment, physical assets, and material needed, and/or it may present specific resources, such as specific equipment needed for the process segment. A process segment may list the quantity of the resource needed.
Process Segment Parameter	Attribute	Specific parameters required for a process segment.
Process Segment Dependency	InternalElement	Process dependencies that are independent of any particular product or operations task.
Personnel Segment Specification	InternalElement	Personnel resources that are required for a process segment.
Personnel Segment Specification Property	Attribute	Specific properties that are required for personnel segment specifications.
Equipment Segment Specification	InternalElement	Equipment resources that are required for a process segment.
Equipment Segment Specification Property	Attribute	Specific properties that are required for equipment segment specifications.
Physical Asset Segment Specification	InternalElement	Physical asset resources that are required for a process segment.
Physical Asset Segment Specification Property	Attribute	Specific properties that are required for physical asset segment specifications.
Material Segment Specification	InternalElement	Material resources that are required for a process segment.
Material Segment Specification Property	Attribute	Specific properties that are required for material segment specifications.

Table 8: Mapping of the IEC 62264-2 process segment model to AML.

3.2 IEC 62264-2 Operations Management Information

Operations management information is information that resembles runtime data from manufacturing – be it specific manufacturing schedules, the produced goods of a production run, or the available personnel in a certain period. While the common object models presented in Clause 3.1 correspond closely to concepts of AML, operations management information is typically not modeled in AML. However, there might be uses cases that require the recording of operations management information, and for these use cases the following alignment is provided.

3.2.1 Operations Definition

An operations definition defines the resources required to perform a specified operation. The operations definition may apply to defining production, maintenance, quality test, and inventory [IEC 62264-2].

An operations definition is modeled as an internal element with its diverse specifications modeled as children internal elements. Operations definitions must refer to role class "OperationsDefinition" that is defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib). The same (but with their corresponding classes) applies to the other internal elements listed in this mapping.
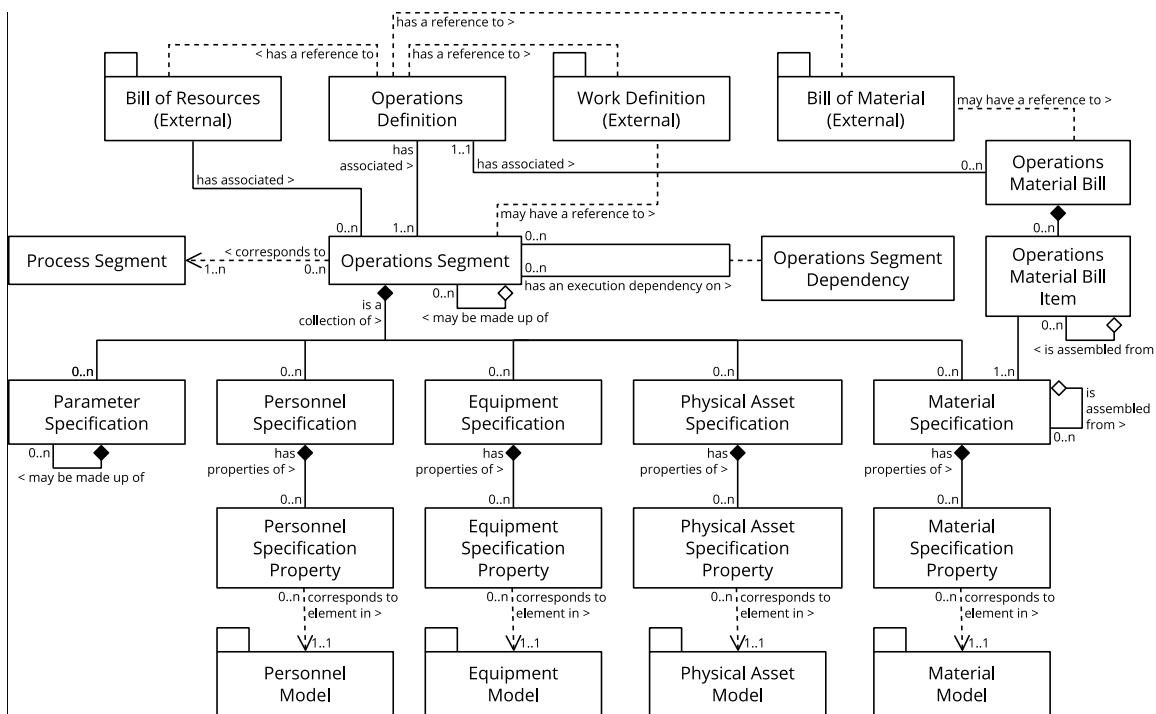
Figure 10: Operations definition model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Operations Definition	InternalElement	Resources required to perform a specified operation.
Operations Material Bill	InternalElement	Collection of all material used in the operation, independent of the process segment the material is used in. There may be multiple operations material bills, with different uses.
Operations Material Bill Item	InternalElement	Items that make up the complete operations material bill.
Operations Segment	InternalElement	Information needed to quantify a segment for a specific operation. It identifies, references, or corresponds to a process segment.
Parameter Specification	Attribute	Specific parameters required for an operations segment. There may be an associated set of zero or more parameter specifications.
Personnel Specification	InternalElement	An identification, reference, or correspondence to a personnel capability. A personnel specification usually specifies a personnel class, but may specify a person.
Personnel Specification Property	Attribute	Specific properties that are required for personnel specifications.
Equipment Specification	InternalElement	An identification, reference, or correspondence to an equipment capability. An equipment specification may specify either an equipment class or a piece of equipment.
Equipment Specification Property	Attribute	Specific properties that are required for equipment specifications.
Physical Asset Specification	InternalElement	An identification, reference, or correspondence to a physical asset capability. A physical asset specification may specify either a physical asset class or a physical asset.
Physical Asset Specification Property	Attribute	Specific properties that are required for physical asset specifications.
Material Specification	InternalElement	An identification or correspondence to a material capability. A material specification specifies a material definition or a material class.
Material Specification Property	Attribute	Specific properties that are required for material specifications.
Operations Segment Dependency	InternalElement	Operations dependencies that are operation or product specific.

Table 9: Mapping of the IEC 62264-2 operations definition model to AML.

3.2.2   Operations Schedule

A request for operations to be performed is an operations schedule. The schedule may apply to scheduling of production, maintenance, quality test, and inventory operations [IEC 62264-2].

An operations schedule is modeled as an internal element with its diverse requirements modeled as children internal elements. Operations schedules must refer to role class "OperationsSchedule" that is defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib). The same (but with their corresponding classes) applies to the other internal elements listed in this mapping.
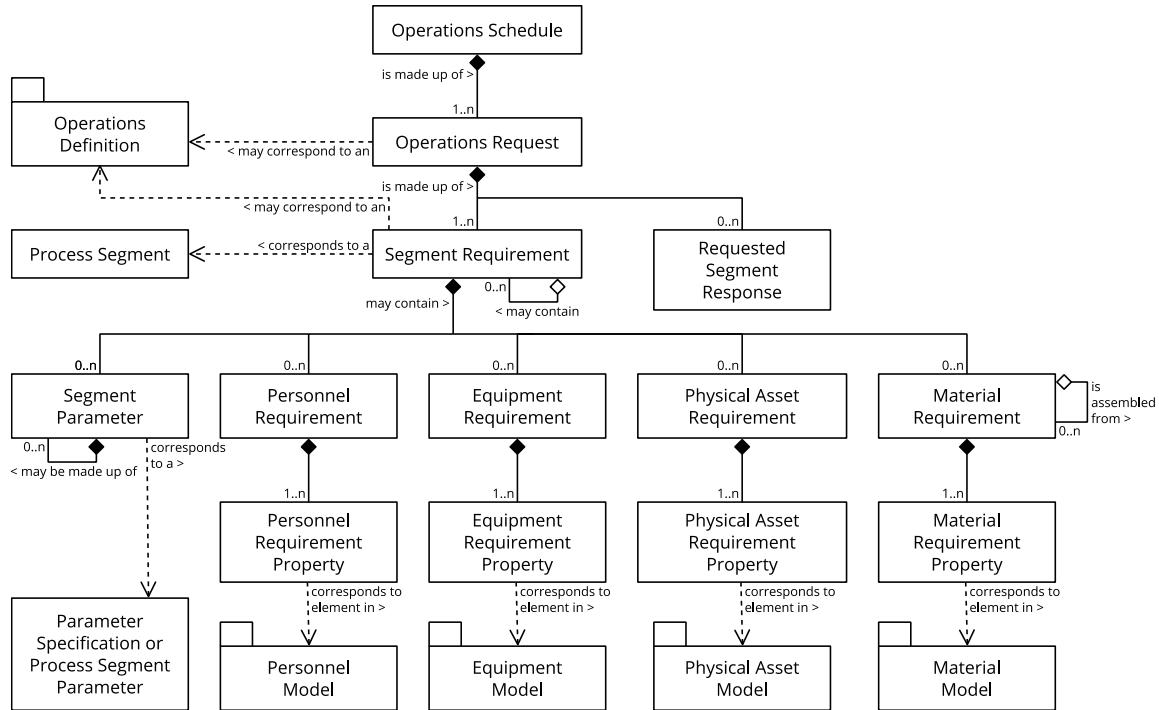
Figure 11: Operations schedule model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Operations Schedule	InternalElement	Request for operations to be performed. An operations schedule shall be made up of one or more operations requests.
Operations Request	InternalElement	Request for an element of an operations schedule. Contains the information required by manufacturing to fulfill the scheduled operation.
Segment Requirement	InternalElement	An operations request shall be made up of one or more segment requirements. Each segment requirement shall correspond to, or reference, an identified operations segment or process segment.
Segment Parameter	InternalElement	Specific parameters required for a segment requirement.
Personnel Requirement	InternalElement	Identification of the number, type, duration, and scheduling of specific certifications and job classifications needed to support the current operations request.
Personnel Requirement Property	Attribute	Specific properties that are required for personnel requirements.
Equipment Requirement	InternalElement	Identification of the number, type, duration, and scheduling of specific equipment and equipment classifications needed to support the current operations request.
Equipment Requirement Property	Attribute	Specific properties that are required for equipment requirements.
Physical Asset Requirement	InternalElement	Identification of the number, type, duration, and scheduling of specific physical assets and physical asset class constraints needed to support the current operations request.
Physical Asset Requirement Property	Attribute	Specific properties that are required for physical asset requirements.
Material Requirement	InternalElement	Identification of a material that is expected to be used in the operations request. Material requirements contain definitions of materials that may be consumed, produced, replaced, sampled, or otherwise used in manufacturing
Material Requirement Property	Attribute	Properties of a material requirement.
Requested Segment Response	InternalElement	Identification of the information sent back as a result of the production request. This information is of the same form as a segment response, but without actual values.

Table 10: Mapping of the IEC 62264-2 operations schedule model to AML.

3.2.3 Operations Performance

Operations performance is a report on requested manufacturing and is a collection of operations responses. Operations responses are responses from manufacturing that may be associated with an operations request. There may be one or more operations responses for a single operations request, if the manufacturing facility needs to split the operations request into smaller elements [IEC 62264-2].

An operations performance is modeled as an internal element with its diverse actuals modeled as children internal elements. Operations performances must refer to role class "OperationsPerformance" that is defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib). The same (but with their corresponding classes) applies to the other internal elements listed in this mapping.
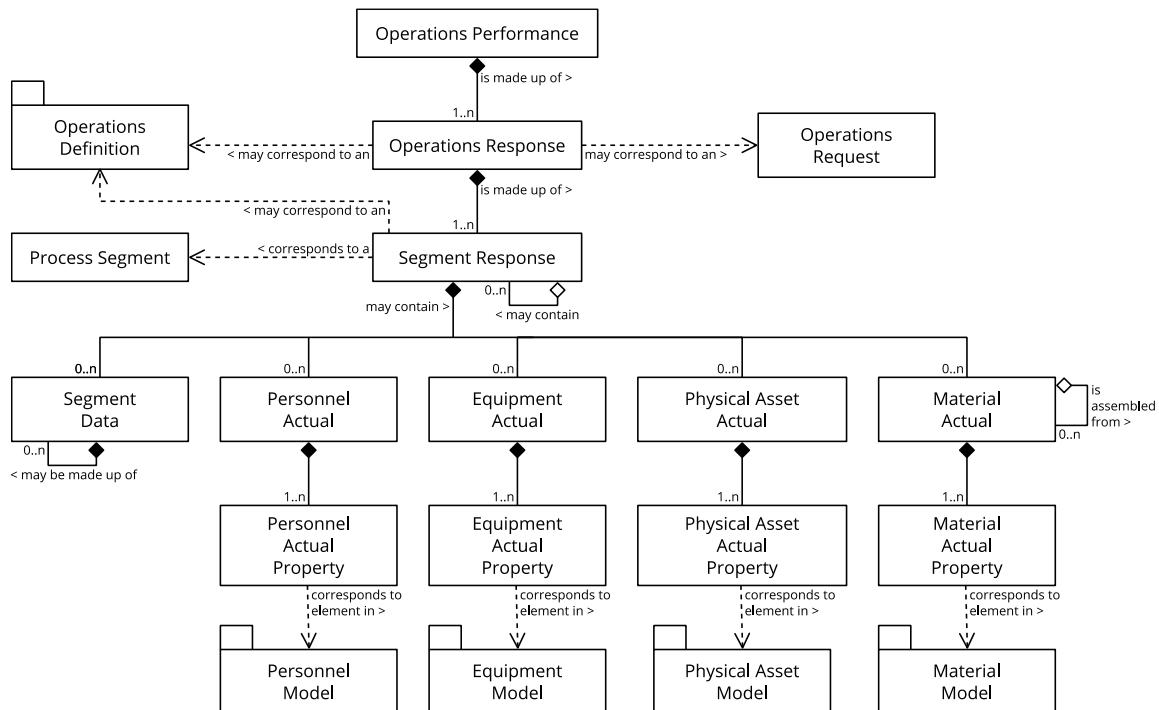
Figure 12: Operations performance model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Operations Performance	InternalElement	Performance of the requested manufacturing requests. Operations performance shall be a collection of operations responses.
Operations Response	InternalElement	Responses from manufacturing that are associated with an operations request. There may be one or more operations responses for a single operations request.
Segment Response	InternalElement	Information on a segment of an operations response. A segment response shall be made up of zero or more sets of information on segment data, personnel actual, equipment actual, and material actual
Segment Data	InternalElement	Other information related to the actual operations made.
Personnel Actual	InternalElement	Identification of a personnel capability used during a specified segment response.
Personnel Actual Property	Attribute	Specific properties that are required for a personnel actual.
Equipment Actual	InternalElement	Identification of an equipment capability used during a specified segment.
Equipment Actual Property	Attribute	Specific properties that are required for an equipment actual.
Physical Asset Actual	InternalElement	Identification of a physical asset capability used during a specified segment.
Physical Asset Actual Property	Attribute	Specific properties that are required for a physical asset actual.
Material Actual	InternalElement	Identification of a material that was used in the operations request. Material actuals contain definitions of materials that may have been consumed, produced, replaced, sampled, or otherwise used in manufacturing.
Material Actual Property	Attribute	Specific properties that are required for a material actual.

Table 11: Mapping of the IEC 62264-2 operations performance model to AML.

3.2.4 Operations Capability

Operations capability information is the collection of information about all resources for operations for selected future and past times. This is made up of information about equipment, physical assets, material, personnel, and process segments. Operations capability describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge [IEC 62264-2]. The process segment capability element is described in detail in Clause 3.2.5.

An operations capability is modeled as an internal element with its diverse capabilities modeled as children internal elements. Operations capabilities must refer to role class "OperationsCapability" that is defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib). The same (but with their corresponding classes) applies to the other internal elements listed in this mapping.
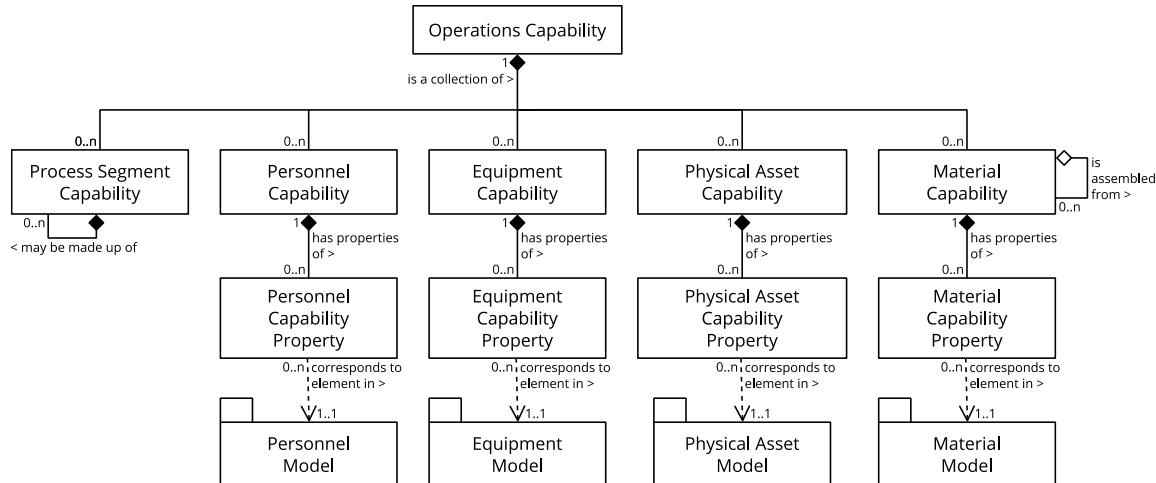
Figure 13: Operations capability model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Operations Capability	InternalElement	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).
Personnel Capability	InternalElement	Capability of persons or personnel classes that is committed, available, or unattainable for a defined time.
Personnel Capability Property	Attribute	Specific properties that are required for personnel capabilities.
Equipment Capability	InternalElement	Representation of the capability of equipment or equipment classes that is committed, available, or unattainable for a specific time.
Equipment Capability Property	Attribute	Specific properties that are required for equipment capabilities.
Physical Asset Capability	InternalElement	Representation of the capability of a physical asset or physical asset class that is committed, available, or unattainable for a specific time.
Physical Asset Capability Property	Attribute	Specific properties that are required for physical asset capabilities.
Material Capability	InternalElement	Representation of the capability of material that is committed, available, or unattainable for a specific time. Material capability is used for material lots and material sublots.
Material Capability Property	Attribute	Specific properties that are required for material capabilities.

Table 12: Mapping of the IEC 62264-2 operations capability model to AML.

3.2.5 Process Segment Capability

Representation of logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a defined process segment for a specific time. The model's structure is equivalent to the one of operations capability, except that a process segment capability is defined for a specific process segment. As such, the various capabilities and capability properties described in Table 12 (Clause 3.2.4) provide the same semantics and structure as the ones required for process segment capabilities. A duplication of the mapping is therefore omitted.

A process segment capability is modeled as an internal element with its diverse capabilities modeled as children internal elements. Process segment capabilities must refer to role class "ProcessSegmentCapability" that is defined in the accompanying role class library (AutomationMLIEC62264RoleClassLib). The same (but with their corresponding classes) applies to the other internal elements listed in this mapping.
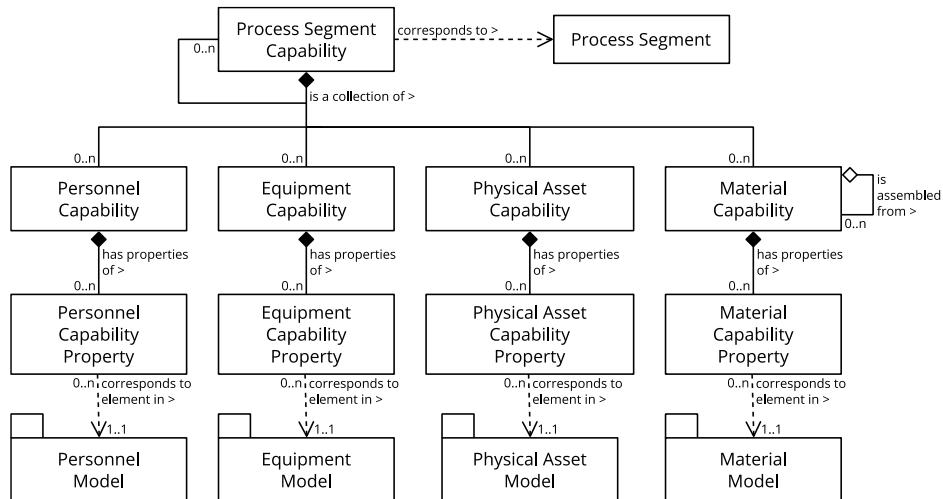

Figure 14: Process segment capability model (from [IEC 62264-2], graphically adapted).

IEC 62264-2	AutomationML	Comment
Process Segment Capability	InternalElement	Representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a given process segment for a specific time.

Table 13: Mapping of the IEC 62264-2 process segment capability model to AML.

3.3 Visualization of the Mapping

Figure 15 depicts a visual approach to the mapping of IEC 62264-2 metamodel elements (i) to CAEX metamodel elements and (ii) to existing AutomationML elements of the AutomationMLBaseRoleClassLib. IEC 62264-2 elements are located in the center column.

Mappings to the left have the following semantics: "An instance of type <X> of the IEC 62264-2 metamodel is modeled as an instance of type <Y> of the CAEX metamodel".

Mappings to the right have the following semantics: "A role class that resembles type <X> of the IEC 62264-2 metamodel is a subclass of <Y> of the AutomationML base role class library". These mappings are complemented by Clause 4.3.1.
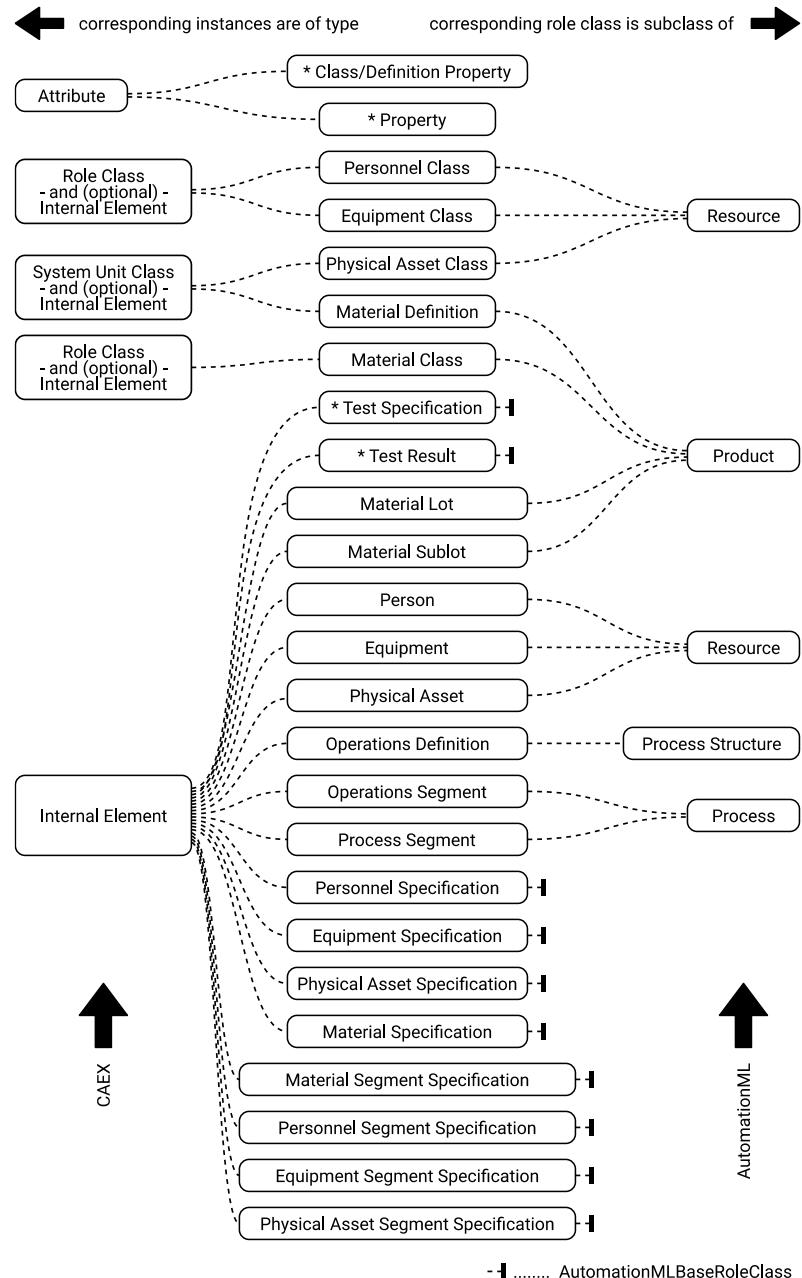
Figure 15: Visualization of the mapping from IEC 62264-2 to the CAEX metamodel (left) and to existing AutomationML elements of the AutomationMLBaseRoleClassLib (right).

NOTE: *Not all IEC 62264-2 elements have been regarded in Figure 15, but a representative selection.*

4 Related AutomationML Libraries

4.1 AutomationML Interface Class Libraries

4.1.1 AutomationMLInterfaceClassLib

Table 14 depicts the interface classes defined in AML parts 1 and 2. With the "ExternalDataConnector" AML defines the basic abstract interface type for referencing external documents. "COLLADAInterface" and "PLCopenXMLInterface" are two standardized interface classes for referencing elements from COLLADA and PLCopen XML files, respectively.

Interface class "ExternalDataReference" is a direct successor to the previously stated interface class "ExternalDataConnector". It contains two attributes: "refURI" (inherited from ExternalDataConnector) gives the URI to the external data file, while "MIMEtype" provides information about the type of content stored in that location. This interface class is required for the referencing of externally stored data in B2MML documents (cf. Clause 6).

InterfaceClass Library	InterfaceClass	Description

AutomationMLInterfaceClassLib
  AutomationMLBaseInterface
   Order
   Port
   PPRConnector
   ExternalDataConnector
    COLLADAInterface
    PLCopenXMLInterface
    ExternalDataReference
  Communication
   SignalInterface
	AutomationMLBaseInterface	Basic abstract interface type, to be used as parent for the description of all AML interface classes.

	ExternalDataReference	Shall be used in order to reference external documents out of the scope of AutomationML.

Table 14: Interface classes of the AutomationMLInterfaceClassLib.

4.2 AutomationML Role Class Libraries

4.2.1 AutomationMLBaseRoleClassLib

AutomationMLBaseRoleClassLib (cf. Table 15) defines entities that resemble abstractions of concepts defined in IEC 62264, subsumed under the term "Process-Product-Resource" (PPR). It defines abstract role types for non-hierarchical elements ("Process", "Product", and "Resource"), as well as for hierarchical elements ("ProcessStructure", "ProductStructure", and "ResourceStructure") [IEC 62714-1]. This is the most generic definition of AML role classes with respect to IEC 62264-2, and as such a corresponding role class defined in this library are used as the super role class of IEC 62264-2 related role classes, if applicable. A mapping of elements from IEC 62264-2 to PPR is given in Clause 4.3.1, a more detailed implementation in AML follows in Clause E.3.

Role class "ExternalData" serves as the base role class for the role class specifying external B2MML documents. The derived role class is declared in a dedicated role class library (cf. Clause 5.2).

RoleClass Library	RoleClass	Description

▣ AutomationMLBaseRoleClassLib
   ℝℂ AutomationMLBaseRole
     ℝℂ Group
     ℝℂ Facet
     ℝℂ Resource
     ℝℂ Product
     ℝℂ Process
     ℝℂ Structure
       ℝℂ ProductStructure
       ℝℂ ProcessStructure
       ℝℂ ResourceStructure
   ℝℂ ExternalData
	AutomationMLBaseRole	Basic abstract role type and the base class for all standard or user-defined role classes.

	Resource	Basic abstract role type and the base class for all AML resource roles. It describes plants, equipment, workers or other production resources.
	Product	Basic abstract role type and the base class for all AML product roles. It describes products, product parts or product related materials that are processed in the described plant.
	Process	Basic abstract role class and the base class for all AML process roles. It describes production related processes.
	Structure	Basic abstract role type for objects that serve as structure elements in the plant hierarchy, e.g. a folder, a site or a manufacturing line.
	ProductStructure	Abstract role type for a product oriented object hierarchy.
	ProcessStructure	Abstract role type for a process oriented object hierarchy.
	ResourceStructure	Abstract role type for a resource oriented object hierarchy.
	ExternalData	Tagging role class for the referencing of external documents.

Table 15: Selected role classes of the AutomationMLBaseRoleClassLib.

NOTE: Role class "Resource" is the (indirect) base class for elements described in the AutomationMLBMIRoleClassLib, AutomationMLCMIRoleClassLib, AutomationMLDMIRoleClassLib, and the AutomationMLCSRoleClassLib. It is also the (indirect) base class for non-hierarchical elements in the (non-normative) AutomationMLExtendedRoleClassLib other than "PLCFacet" and "HMIFacet".

NOTE: Role class "ResourceStructure" is the (indirect) base class for hierarchical elements in the (non-normative) AutomationMLExtendedRoleClassLib.

4.2.2   AutomationMLBMIRoleClassLib

Table 16 depicts a base role class related to batch manufacturing. The role class "BatchManufacturingEquipment" inherits from AML base role "Resource" and could be used as an additional supported role class for internal elements representing equipment or physical asset items.

RoleClass Library	RoleClass	Description
AutomationMLBMIRoleClassLib BatchManufacturingEquipment	BatchManufacturingEquipment	Equipment related to batch manufacturing.

Table 16: Role class of the AutomationMLBMIRoleClassLib.

4.2.3   AutomationMLCMIRoleClassLib

Table 17 depicts a base role class related to continuous manufacturing. The role class "ContManufacturingEquipment" inherits from AML base role "Resource" and could be used as an additional supported role class for internal elements representing equipment or physical asset items.

RoleClass Library	RoleClass	Description
AutomationMLCMIRoleClassLib ContManufacturingEquipment	ContManufacturingEquipment	Equipment related to continuous manufacturing.

Table 17: Role class of the AutomationMLCMIRoleClassLib.

4.2.4 AutomationMLDMIRoleClassLib

Table 18 lists role classes related to discrete manufacturing. The top-level role class "DiscManufacturingEquipment" (from which the other role classes of this library directly inherit) inherits from AML base role "Resource" and could be used as an additional supported role class for internal elements representing equipment or physical asset items.

RoleClass Library	RoleClass	Description

AutomationMLDMIRoleClassLib
  DiscManufacturingEquipment
    Transport
    Storage
    Fixture
    Gate
    Robot
    Tool
    Carrier
    Machine
    StaticObject
	DiscManufacturingEquipment	Equipment related to discrete manufacturing industries.

	Transport	Equipment that performs transport processes to transfer items.
	Storage	Equipment that is used to buffer products or material temporarily within the plant. It can also be used to feed products or materials into the production process or to export products or materials out of the production process.
	Fixture	Equipment that reduces the degrees of freedom of an item.
	Gate	Equipment that can block or monitor an entrance, departure, or passage way.
	Robot	Role class used for robots.
	Tool	Equipment used by resources that is necessary for or aids in the performance of an operation on the product.
	Carrier	Transport equipment that carries items.
	Machine	Mechanic or mechatronic equipment that creates added value on products and is designed expressly to perform specific tasks.
	StaticObject	Passive, static items positioned in the production environment.

Table 18: Role classes of the AutomationMLDMIRoleClassLib.

4.2.5 AutomationMLCSRoleClassLib

Table 19 lists role classes related to control system equipment (applicable to batch, continuous, and discrete manufacturing). The top-level role class "ControlEquipment" (from which the other role classes of this library directly or indirectly inherit) inherits from AML base role "Resource" and could be used as an additional supported role class for internal elements representing equipment or physical asset items.

RoleClass Library	RoleClass	Description

AutomationMLCSRoleClassLib
  ControlEquipment
    Communication
    ControlHardware
      PC
      IPC
      EmbeddedDevice
      Handheld
    Sensor
    Actuator
    Controller
      PLC
      NC
      RC
      PAC
	ControlEquipment	Equipment related to a control system. ControlEquipment can be used for every type of industry.

	Communication	Items dedicated to communications.
	ControlHardware	Hardware that provides runtime environments.
	PC	Any general-purpose computer that provides runtime environments for software being executed on it.
	IPC	Any PC-based computing platform for industrial applications that provides runtime environments for software being executed on it.
	EmbeddedDevice	Any device designed to perform one or a few dedicated software functions. It is embedded as part of another device often including hardware and mechanical parts.
	Handheld	Any portable, programmable, electronic device with an own power supply for particular applications.
	Sensor	Role class used for sensors.
	Actuator	Role class used for actuators.
	Controller	Self-acting functionalities that process signals according to a predefined logic and generate output signals in order to reach an intended behavior of technical processes.
	PLC	Programmable Logic Controller: Programmable control functionality focusing on the processing of signals.
	NC	Numerical Control: Programmable control functionality focusing on the processing of numerical signals.
	RC	Programmable control functionality driving robots in order to reach an intended behavior of the robot kinematic system and corresponding connected periphery.
	PAC	Programmable Automation Controller: Programmable automation functionality focusing on cross-domain functionality like binary, motion, and continuous control.

Table 19: Role classes of the AutomationMLCSRoleClassLib.

4.2.6 AutomationML Extended RoleClass Library (non-normative)

Table 20 lists more specific role classes that are extending corresponding role classes of the previously discussed role class libraries (cf. Clauses 4.2.1 to 4.2.5). All listed role classes (except for "PLCFacet" and "HMIFacet") inherit directly or indirectly from AML base role "Resource" and could be used as an additional supported role class for internal elements representing equipment or physical asset items. In Table 20 only role classes that are specifically relevant for this recommendation are explicitly named and commented: an AML object that resembles an an IEC 62264 element of type equipment or equipment class that has the equipment level "Enterprise" shall be associated with the role class "Enterprise" from the AutomationMLExtendedRoleClassLib (e.g. through the addition of a "supported role class"). The same rule shall apply to the other hierarchical elements of the role based equipment model correspondingly ("Site", "Area", "ProductionLine", …).

RoleClass Library	RoleClass	Description
AutomationMLExtendedRoleClassLib	Enterprise	Role class used for business structures.
PLCFacet	Site	Physical, geographical, or logical grouping determined by the enterprise. It may contain areas, production lines, process cells, and production units.
HMIFacet		
Enterprise		
Site	Area	Physical, geographical, or logical grouping determined by the site. It may contain work centers such as production lines, process cells, production units, and storage zones.
Area		
ProductionLine		
WorkCell		
ProcessCell	ProductionLine	Equipment for discrete manufacturing at the production line level.
Unit		
ProductionUnit	WorkCell	Equipment for discrete manufacturing at the work cell level.
StorageZone		
StorageUnit	ProcessCell	Equipment for batch manufacturing at the process cell level.
Turntable		
Conveyor	Unit	Linked chained production plants in batch manufacturing.
BeltConveyor		
RollConveyor	ProductionUnit	Lowest level of equipment for continuous manufacturing processes.
ChainConveyor		
PalletConveyor	StorageZone	Work center for material movement equipment.
OverheadConveyor		
LiftingTable	StorageUnit	Work unit for material movement equipment.
AGV		
Transposer		
CarrierHandlingSystem		
BodyStore		
Lift		
Rollerbed		
StationaryTool		
MovableTool		
ControlCabinet		
IODevice		
HMI		
WarningEquipment		
ActuatingDrive		
MotionController		
Panel		
MeasuringEquipment		
Clamp		
ProcessController		
Loader		
Unloader		

Table 20: Role classes of the AutomationMLExtendedRoleClassLib.

NOTE: Some of the elements in the (non-normative) AML extended role class library are roles that have been derived from IEC 62264-1 (role classes "Site" to "StorageUnit"), but there are two issues with those elements: (i) in the current implementation of the extended role class library it is that the work unit "Unit" is included only with reference to batch manufacturing – however, in IEC 62264-1 "Unit" is the name for work units in batch and in continuous production, and (ii) role classes for generic work cells and work units should be provided (not only the more specific ones: "ProductionLine", "ProcessCell", "ProductionUnit", "StorageZone", "WorkCell", "Unit", and "StorageUnit"), as this is proposed in IEC 62264-1. As such, a corresponding revision of the extended role class library is proposed and might be implemented in future versions of AutomationMLExtendedRoleClassLib (this is out of scope of this recommendation).

4.3 Alignment of IEC 62264-2 and AutomationML

An alignment of IEC 62264-2 with generic PPR role classes is given in Clause 4.3.1, while an alignment with more detailed AutomationML role classes is depicted in Clause 4.3.2. It depends on the implementer's domain knowledge at which detail he/she wants to annotate his/her elements.

4.3.1 Alignment of IEC 62264-2 and AutomationMLBaseRoleClassLib

Role classes "Resource", "Product", "Process", "ProductStructure", "ProcessStructure", and "ResourceStructure", which are defined in the AutomationMLBaseRoleClassLib of IEC 62714-1 (cf. Clause 4.2.1), are related to concepts in IEC 62264-2 (cf. Clause 4.2).

A mapping of related concepts from IEC 62264-2 and AML base role classes is given in Table 21 ("AutomationMLBaseRoleClassLib/AutomationMLBaseRole" is abbreviated as "BR" for better readability). The other concepts of IEC 62264-2 are not directly related to any of the existing base roles of AML – they are therefore not listed here. The mappings listed here correspond to the inheritance relation of IEC 62264-2 role classes that are defined in Clause 5.3, e.g., role class "BR/Resource" is the super role class of the newly defined IEC 62264 role class "Equipment".

NOTE: Some of the mappings are also visualized in Figure 15.

IEC 62264-2	Automation ML Base Role Class	Comment
Person	BR/Resource	Representation of a specifically identified individual. A person may be a member of zero or more personnel classes.
Personnel Class	BR/Resource	Representation of a grouping of persons with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability, and performance.
Equipment	BR/Resource	Representation of the elements of the equipment hierarchy model.
Equipment Class	BR/Resource	Representation of a grouping of equipment with similar characteristics.
Physical Asset	BR/Resource	A physical piece of equipment shall be presented as a physical asset. Any physical asset shall be a member of one physical asset class.
Physical Asset Class	BR/Resource	A representation of a grouping of physical assets with similar characteristics for purposes of repair and replacement.
Material Definition	BR/Product	Representation of goods with similar name characteristics for the purpose of manufacturing definition, scheduling, capability and performance.
Material Class	BR/Product	Representation of groupings of material definitions for a definite purpose such as manufacturing operations definition, scheduling, capability and performance.
Material Lot	BR/Product	Uniquely identified specific amount of material, either countable or weighable. A material lot describes the planned or actual total quantity or amount of material available, its current state, and its specific property values.
Material Sublot	BR/Product	Separately identifiable quantity of the same material lot.
Process Segment	BR/Process	Lists the classes of personnel, equipment, physical assets, and material needed, and/or it may present specific resources, such as specific equipment needed for the process segment. A process segment may list the quantity of the resource needed.
Operations Definition	BR/Structure/ ProcessStructure	Resources required to perform a specified operation.
Operations Segment	BR/Process	Information needed to quantify a segment for a specific operation. An operations segment identifies, references, or corresponds to a process segment.
Operations Schedule	BR/Structure/ ProcessStructure	Request for operations to be performed. An operations request shall be made up of one or more operations requests.
Operations Request	BR/Structure/ ProcessStructure	Request for an element of an operation schedule. An operations request contains the information required by manufacturing to fulfill the scheduled operation.
Segment Requirement	BR/Process	An operations request shall be made up of one ore more segment requirements. Each segment requirement shall correspond to or reference an identified operations segment or process segment.
Requested Segment Response	BR/Process	Identification of the information sent back as a result of the operations request.

IEC 62264-2	Automation ML Base Role Class	Comment
Operations Performance	BR/Structure/ ProcessStructure	Performance of the requested operations.
Operations Response	BR/Structure/ ProcessStructure	Response from manufacturing that is associated with an operations request. There may be one or more operations responses for a single operations request if the manufacturing facility needs to split the operations request into smaller elements.
Segment Response	BR/Process	Information on a segment of an operations response.
Operations Capability	BR/Process	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.
Process Segment Capability	BR/Process	Representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a defined process segment for a specific time.

Table 21: Alignment of IEC 62264-2 with AML base role classes.

4.3.2   Alignment of IEC 62264-2 and Detailed Normative AutomationML Role Class Libraries

In addition to the generic role classes discussed in Clause 4.3.1, more detailed role classes are defined in IEC 62714-2 in the role class libraries "AutomationMLBMIRoleClassLib", "AutomationMLCMIRoleClassLib", "AutomationMLDMIRoleClassLib", and "AutomationMLCSRoleClassLib" (cf. Clauses 4.2.2 - 4.2.5).

All the role classes defined in these libraries inherit directly or indirectly from the base role class (cf. Clause 4.2.1) "AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource" and can be applied to any of the IEC 62264-2 concepts listed in Table 22. Application of any of these role classes can be realized as additional "supported role class".

IEC 62264-2	AutomationML
Equipment Equipment Class Physical Asset Physical Asset Class	AutomationMLCSRoleClassLib/ControlEquipment
	AutomationMLCSRoleClassLib/ControlEquipment/Communication
	AutomationMLCSRoleClassLib/ControlEquipment/ControlHardware
	AutomationMLCSRoleClassLib/ControlEquipment/ControlHardware/PC
	AutomationMLCSRoleClassLib/ControlEquipment/ControlHardware/IPC
	AutomationMLCSRoleClassLib/ControlEquipment/ControlHardware/EmbeddedDevice
	AutomationMLCSRoleClassLib/ControlEquipment/ControlHardware/Handheld
	AutomationMLCSRoleClassLib/ControlEquipment/Sensor
	AutomationMLCSRoleClassLib/ControlEquipment/Actuator
	AutomationMLCSRoleClassLib/ControlEquipment/Controller
	AutomationMLCSRoleClassLib/ControlEquipment/Controller/PLC
	AutomationMLCSRoleClassLib/ControlEquipment/Controller/NC
	AutomationMLCSRoleClassLib/ControlEquipment/Controller/RC
	AutomationMLCSRoleClassLib/ControlEquipment/Controller/PAC
	AutomationMLBMIRoleClassLib/BatchManufacturingEquipment
	AutomationMLCMIRoleClassLib/ContManufacturingEquipment
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Storage
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Fixture
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Gate
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Robot
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Carrier
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Machine
	AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/StaticObject

Table 22: Alignment of IEC 62264-2 with more detailed normative AML role classes.

4.3.3 Alignment of IEC 62264-2 and AutomationMLExtendedRoleClassLib

Even more detailed role classes are defined in IEC 62714-2 in the "AutomationMLExtendedRoleClassLib" role class library (cf. Clause 4.2.6). All the role classes defined in this library (except for the two "Facets") inherit directly or indirectly from role class "AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource" (cf. Clause 4.2.1) and can be applied to any of the IEC 62264-2 concepts listed in Table 23. Application of any of these role classes can be realized as additional "supported role class".

IEC 62264-2	AutomationML
Equipment Equipment Class Physical Asset Physical Asset Class	AutomationMLExtendedRoleClassLib/Enterprise
	AutomationMLExtendedRoleClassLib/Site
	AutomationMLExtendedRoleClassLib/Area
	AutomationMLExtendedRoleClassLib/ProductionLine
	AutomationMLExtendedRoleClassLib/WorkCell
	AutomationMLExtendedRoleClassLib/ProcessCell
	AutomationMLExtendedRoleClassLib/Unit
	AutomationMLExtendedRoleClassLib/ProductionUnit
	AutomationMLExtendedRoleClassLib/StorageZone
	AutomationMLExtendedRoleClassLib/StorageUnit
	AutomationMLExtendedRoleClassLib/Turntable
	AutomationMLExtendedRoleClassLib/Conveyor
	AutomationMLExtendedRoleClassLib/Conveyor/BeltConveyor
	AutomationMLExtendedRoleClassLib/Conveyor/RollConveyor
	AutomationMLExtendedRoleClassLib/Conveyor/ChainConveyor
	AutomationMLExtendedRoleClassLib/Conveyor/PalletConveyor
	AutomationMLExtendedRoleClassLib/Conveyor/OverheadConveyor
	AutomationMLExtendedRoleClassLib/LiftingTable
	AutomationMLExtendedRoleClassLib/AGV
	AutomationMLExtendedRoleClassLib/Transposer
	AutomationMLExtendedRoleClassLib/CarrierHandlingSystem
	AutomationMLExtendedRoleClassLib/BodyStore
	AutomationMLExtendedRoleClassLib/Lift
	AutomationMLExtendedRoleClassLib/Rollerbed
	AutomationMLExtendedRoleClassLib/StationaryTool
	AutomationMLExtendedRoleClassLib/MovableTool
	AutomationMLExtendedRoleClassLib/ControlCabinet
	AutomationMLExtendedRoleClassLib/IODevice
	AutomationMLExtendedRoleClassLib/HMI
	AutomationMLExtendedRoleClassLib/HMI/WarningEquipment
	AutomationMLExtendedRoleClassLib/ActuatingDrive
	AutomationMLExtendedRoleClassLib/MotionController
	AutomationMLExtendedRoleClassLib/Panel
	AutomationMLExtendedRoleClassLib/MeasuringEquipment
	AutomationMLExtendedRoleClassLib/Clamp
	AutomationMLExtendedRoleClassLib/ProcessController
	AutomationMLExtendedRoleClassLib/Loader
	AutomationMLExtendedRoleClassLib/Unloader

Table 23: Alignment of IEC 62264-2 with the (non-normative) AML extended role class lib.

5 AML Libraries for Supporting IEC 62264

5.1 Interface Class Library AutomationMLIEC62264InterfaceClassLib

Interface class library AutomationMLIEC62264InterfaceClassLib (cf. Table 24) specifies a number of interface classes required for the modeling of IEC 62264 information with AML by enabling required cross-references.

InterfaceClass Library	RoleClass	Description

AutomationMLIEC62264InterfaceClassLib
  HierarchyScopeConnector
  ResourceConnector
  EquipmentAssetConnector
  DependencyConnector
  TestConnector
	HierarchyScopeConnector	HierarchyScopeConnector shall be used in order to reference hierarchy scope elements from other entities such as e.g., process segments.

	ResourceConnector	ResourceConnector shall be used in order to reference basic or complex resources from complex entities such as e.g., a person or personnel class from a personnel segment specification of a process segment.
	EquipmentAssetConnector	EquipmentAssetConnector shall be used in order to link equipment and physical assets to equipment asset mappings.
	DependencyConnector	DependencyConnector shall be used in order to link process or operations segments to process or operations segment dependencies, respectively.
	TestConnector	TestConnector shall be used in order to link resources and resource types to test specifications and test results.

Table 24: Interface classes needed for supporting concepts of IEC 62264, subsumed in the AutomationMLIEC62264InterfaceClassLib.

InterfaceClass "HierarchyScopeConnector" shall be used as specified in Table 25: one instance of this interface class is to be bound to an element of type "HierarchyScope" (cf. Clause 5.3.1), while another instance of this interface class is to be instantiated at a "scopable" IEC 62264 element. Then, an internal link is to be created, thus reifying the relation (cf. Figure 16).

Class Name	HierarchyScopeConnector
Description	The InterfaceClass "HierarchyScopeConnector" shall be used in order to reference hierarchy scope elements from other entities such as e.g., process segments.
Parent Class	AutomationMLInterfaceClassLib/AutomationMLBaseInterface
Path for Element Reference	AutomationMLIEC62264InterfaceClassLib/HierarchyScopeConnector

Table 25: Interface class HierarchyScopeConnector.
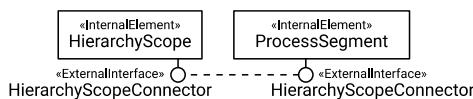
Figure 16: Usage example for interface class HierarchyScopeConnector.

InterfaceClass "ResourceConnector" shall be used as specified in Table 26: one instance of this interface class is to be bound to an element of any of the basic resource types (e.g., equipment or equipment class), while another instance of this interface class is to be instantiated at a "referring" IEC 62264 element (e.g., equipment segment specification). Then, an internal link is to be created, thus reifying the relation (cf. Figure 17). Another use case is the referencing of complex structures, e.g., for expressing the relation of an operations segment to a process segment.

Class Name	ResourceConnector
Description	The InterfaceClass "ResourceConnector" shall be used in order to reference basic resources from complex entities such as e.g., a personnel segment specification of a process segment referring to a person or personnel class.
Parent Class	AutomationMLInterfaceClassLib/AutomationMLBaseInterface
Path for Element Reference	AutomationMLIEC62264InterfaceClassLib/ResourceConnector

Table 26: Interface class ResourceConnector.
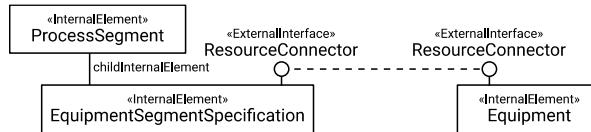
Figure 17: Usage example for interface class ResourceConnector.

InterfaceClass "EquipmentAssetConnector" shall be used as specified in Table 27: one instance of this interface class is bound to an equipment, while the other is bound to an equipment asset mapping. At the same time, another instance of this interface class is bound to a physical asset. Then, two internal links are created that interlink (i) the equipment with the equipment asset mapping and (ii) the physical asset with the equipment asset mapping (cf. Figure 18).

Class Name	EquipmentAssetConnector
Description	The InterfaceClass "EquipmentAssetConnector" shall be used in order to link Equipment and PhysicalAssets to EquipmentAssetMappings.
Parent Class	AutomationMLInterfaceClassLib/AutomationMLBaseInterface
Path for Element Reference	AutomationMLIEC62264InterfaceClassLib/EquipmentAssetConnector

Table 27: Interface class EquipmentAssetConnector.
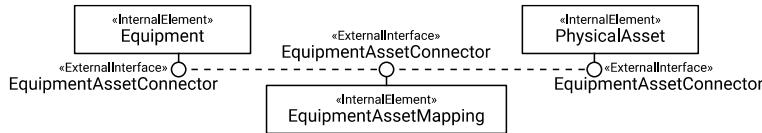
Figure 18: Usage example of interface class EquipmentAssetConnector.

InterfaceClass "DependencyConnector" shall be used as specified in Table 28: one instance of this interface class is bound to a process segment or operations segment, while the other is bound to a process segment dependency or operations segment dependency, respectively. At the same time, another instance of this interface class is bound to another process segment or operations segment. Then, two internal links are created that interlink the process segments or operations segments with the process segment dependency or the operations segment dependency, respectively (cf. Figure 19). Whether the connected segment is the "host" or the "dependency" instance, is defined by an attribute "role" that must be defined in instances of dependency connector that are bound to process or operations segment dependency entities.

Class Name	DependencyConnector	
Description	The InterfaceClass "DependencyConnector" shall be used in order to link ProcessSegments and OperationsSegments to Process/OperationsSegmentDependencies.	
Parent Class	AutomationMLInterfaceClassLib/AutomationMLBaseInterface	
Path for Element Reference	AutomationMLIEC62264InterfaceClassLib/DependencyConnector	
Attributes	role (type="xs:string")	Identifies whether the segment the interface is attached to is the source ("host") or the target ("dependency") of this dependency relation. One of (nominal scaled constraint): "host", "dependency". Only required for the dependency connectors attached to the process or operations segment dependency.

Table 28: Interface class DependencyConnector.
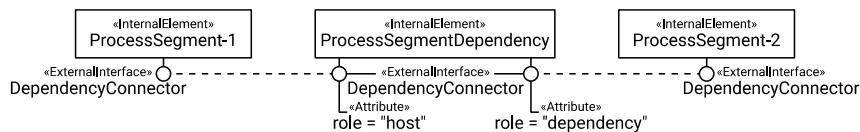
Figure 19: Usage example of interface class DependencyConnector.

InterfaceClass "TestConnector" shall be used as specified in Table 29: one instance of this interface class is bound to a resource or resource type (e.g., person, personnel class, equipment, equipment class), while the other is bound to a test specification or test result. Then, internal links are created to interlink the resource or resource type with the test specification or test result, as well as the test result with the test specification (cf. Figure 20). If the test specification needs to specify a resource property or resource type property, it shall instantiate an attribute with the same name as the one referring to, but prefixed with "ts:". If the test result needs to specify a resource property or resource type property, it shall instantiate an attribute with the same name as the one referring to, but prefixed with "tr:".

Class Name	TestConnector
Description	The InterfaceClass "TestConnector" shall be used in order to link ProcessSegments and OperationsSegments to Process/OperationsSegmentDependencies.
Parent Class	AutomationMLInterfaceClassLib/AutomationMLBaseInterface
Path for Element Reference	AutomationMLIEC62264InterfaceClassLib/TestConnector

Table 29: Interface class TestConnector.
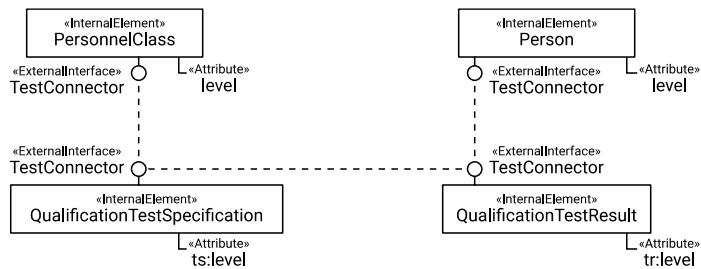
Figure 20: Usage example for interface class TestConnector.

5.2 Role Class Library AutomationMLB2MMLRoleClassLib

Role class library "AutomationMLB2MMLRoleClassLib", as depicted in Table 30, is encapsulating role classes that are required for the use of externally linked B2MML documents. It is not required in case all IEC 62264 information is modeled within AML

RoleClass Library	RoleClass	Description
🔲 AutomationMLB2MMLRoleClassLib 🔳 B2mmlData	B2mmlData	References external B2MML documents.

Table 30: Role class "B2mmlData" needed for referencing a specific B2MML document, encapsulated in the AutomationMLB2MMLRoleClassLib.

NOTE: *IEC 62264 elements such as Personnel Class and Equipment Class that are normally modeled as instances of type RoleClass in AML documents cannot hold instances of type InternalElement that represent external documents. Therefore, they shall be instantiated additionally as an internal element that refers to the correct IEC 62264 role class and this internal element holds another internal element representing an external document.*

RoleClass "B2mmlData" shall be used as specified in Table 31, and as further specified in Clause 6. It corresponds to the specification given in IEC 62714-1, as it is used to tag an AML element as representing an external document. This role class is to be referenced by AML elements that should reference external files through the external interfaces of interface class "ExternalDataReference".

Class Name	B2mmlData
Description	The RoleClass "B2mmlData" shall be used in order to reference external B2MML documents.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/ExternalData
Path for Element Reference	AutomationMLB2MMLRoleClassLib/B2mmlData
Attributes	None

Table 31: Role class B2mmlData.

5.3 Role Class Library AutomationMLIEC62264RoleClassLib

RoleClass Library	RoleClass	Description
AutomationMLIEC62264RoleClassLib	HierarchyScope	Role class used for hierarchy scopes.
HierarchyScope	PersonnelModel	Abstract role class used for structuring personnel roles.
PersonnelModel		
PersonnelClass	PersonnelClass	Role class used for personnel classes.
Person	Person	Role class used for persons.
QualificationTestSpecification	QualificationTest Specification	Role class used for qualification test specifications.
QualificationTestResult	QualificationTestResult	Role class used for qualification test results.
EquipmentModel	EquipmentModel	Abstract role class used for structuring equipment roles.
EquipmentClass	EquipmentClass	Role class used for equipment classes.
Equipment	Equipment	Role class used for equipment.
EquipmentCapabilityTest Specification	EquipmentCapabilityTest Specification	Role class used for equipment capability test specifications.
EquipmentCapabilityTestResult	EquipmentCapabilityTest Result	Role class used for equipment capability test results.
PhysicalAssetModel	PhysicalAssetModel	Abstract role class for structuring physical asset roles.
PhysicalAssetClass	PhysicalAssetClass	Role class used for physical asset classes.
PhysicalAsset	PhysicalAsset	Role class used for physical assets.
PhysicalAssetCapabilityTest Specification	PhysicalAssetCapability TestSpecification	Role class used for physical asset capability test specifications.
PhysicalAssetCapabilityTestResult	PhysicalAssetCapability TestResult	Role class used for physical asset capability test results.
EquipmentAssetMapping	EquipmentAssetMapping	EquipmentAssetMapping is used to link physical assets to equipment.
MaterialModel	MaterialModel	Abstract role class for structuring material roles.
MaterialClass	MaterialClass	Role class used for material classes.
MaterialDefinition	MaterialDefinition	Role class used for material definitions.
MaterialLot	MaterialLot	Role class used for material lots.
MaterialSublot	MaterialSublot	Role class used for material sublots.
MaterialTestSpecification	MaterialTestSpecification	Role class used for material test specifications.
MaterialTestResult	MaterialTestResult	Role class used for material test results.
MaterialAssembly	MaterialAssembly	Role class used for specifying material assemblies.
ProcessSegmentModel		
ProcessSegment		
PersonnelSegmentSpecification		
EquipmentSegmentSpecification		
PhysicalAssetSegmentSpecification		
MaterialSegmentSpecification		
ProcessSegmentDependency		
OperationsDefinitionModel		
OperationsDefinition		
OperationsMaterialBill		
OperationsMaterialBillItem		
OperationsSegment		
PersonnelSpecification		
EquipmentSpecification		
PhysicalAssetSpecification		
MaterialSpecification		
OperationsSegmentDependency		
OperationsScheduleModel		
OperationsSchedule		
OperationsRequest		
SegmentRequirement		
PersonnelRequirement		
EquipmentRequirement		
PhysicalAssetRequirement		

RoleClass Library	RoleClass	Description
- MaterialRequirement - RequestedSegmentResponse OperationsPerformanceModel - OperationsPerformance - OperationsResponse - SegmentResponse - PersonnelActual - EquipmentActual - PhysicalAssetActual - MaterialActual OperationsCapabilityModel - OperationsCapability - PersonnelCapability - EquipmentCapability - PhysicalAssetCapability - MaterialCapability ProcessSegmentCapability	ProcessSegmentModel	Abstract role class for structuring process segment roles.
	ProcessSegment	Role class used for process segments.
	PersonnelSegment Specification	Role class used for personnel segment specifications.
	EquipmentSegment Specification	Role class used for equipment segment specifications.
	PhysicalAssetSegment Specification	Role class used for physical asset segment specifications.
	MaterialSegment Specification	Role class used for material segment specifications.
	ProcessSegment Dependency	Role class used for process segment dependencies.
	OperationsDefinition Model	Abstract role class used for structuring operations definition roles.
	OperationsDefinition	Role class used for operations definitions.
	OperationsMaterialBill	Role class used for operations material bills.
	OperationsMaterialBill Item	Role class used for operations material bill items.
	OperationsSegment	Role class used for operations segments.
	PersonnelSpecification	Role class used for personnel specifications.
	EquipmentSpecification	Role class used for equipment specifications.
	PhysicalAsset Specification	Role class used for physical asset specifications.
	MaterialSpecification	Role class used for material specifications.
	OperationsSegment Dependency	Role class used for operations segment dependencies.
	OperationsSchedule Model	Abstract role class used for structuring operations schedule roles.
	OperationsSchedule	Role class used for operations schedules.
	OperationsRequest	Role class used for operations requests.
	SegmentRequirement	Role class used for segment requirements.
	PersonnelRequirement	Role class used for personnel requirements.

RoleClass Library	RoleClass	Description
	EquipmentRequirement	Role class used for equipment requirements.
	PhysicalAsset Requirement	Role class used for physical asset requirements.
	MaterialRequirement	Role class used for material requirements.
	RequestedSegment Response	Role class used for requested segment responses.
	OperationsPerformance Model	Abstract role class used for structuring operations performance roles.
	OperationsPerformance	Role class used for operations performances.
	OperationsResponse	Role class used for operations responses.
	SegmentResponse	Role class used for segment responses.
	PersonnelActual	Role class used for personnel actual.
	EquipmentActual	Role class used for equipment actual.
	PhysicalAssetActual	Role class used for physical asset actual.
	MaterialActual	Role class used for material actual.
	OperationsCapability Model	Abstract role class used for structuring operations capability roles.
	OperationsCapability	Role class used for operations capabilities.
	PersonnelCapability	Role class used for personnel capabilities.
	EquipmentCapability	Role class used for equipment capabilities.
	PhysicalAssetCapability	Role class used for physical asset capabilities.
	MaterialCapability	Role class used for material capabilities.
	ProcessSegment Capability	Role class used for process segment capabilities.

Table 32: Role classes needed for supporting concepts from IEC 62264, subsumed in the AutomationMLIEC62264RoleClassLib.

Some role classes that are defined in Clauses 5.3.1 to 5.3.11 declare attributes; these attributes have been derived from IEC 62264. All these attributes are optional (it is not required to duplicate information that is stored in other documents) – however, if any of these attributes is used in an AML document its value(s) shall be equal to the value(s) in the referenced B2MML document.

5.3.1 Hierarchy Scope

RoleClass "HierarchyScope" shall be used as specified in Table 33. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "HierarchyScope" as a supported role class or role requirement. The relation to a piece of equipment is realized by adding a mirror object of this equipment as a child internal element to this hierarchy scope. Further, a hierarchy scope may contain other hierarchy scope elements as child internal elements.

Class Name	HierarchyScope	
Description	Role class used for hierarchy scopes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/HierarchyScope	
Attributes (optional)	equipmentElementLevel (type="xs:string")	Identification of the equipment level if the equipment element is defined.

Table 33: Role class HierarchyScope.

5.3.2 Personnel

RoleClass "PersonnelModel" shall be used as specified in Table 34. It is the base structuring role class for all personnel roles, without specific semantics on its own. In the context of IEC 62264, one of the concrete sub roles (or any user defined sub role thereof) of PersonnelModel shall be used as a starting point for AML models.

Class Name	PersonnelModel
Description	Abstract role class used for structuring personnel roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PersonnelModel
Attributes	None

Table 34: Role class PersonnelModel.

RoleClass "PersonnelClass" shall be used as specified in Table 35. Instances of this role class shall be realized as role classes, specifying "PersonnelClass" as parent class. Personnel class instances can be realized as internal elements following a singleton pattern, i.e., only up to one internal element can be created for each personnel class. This internal element can be used e.g., for linking within instance hierarchies, or for referencing external data. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PersonnelClass	
Description	Role class used for personnel classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PersonnelModel/PersonnelClass	
Attributes (optional)	id (type="xs:string")	Unique identification of a specific personnel class. These are not necessarily job titles, but identify classes that are referenced in other parts of the model.

Table 35: Role class PersonnelClass.

User defined attributes for personnel classes ("PersonnelClassProperty") shall be defined as complex attributes as specified in Table 36. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for personnel classes. May be tested by the execution of a qualification test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/PersonnelModel/PersonnelClass	
Attributes	id (type="xs:string")	An identification of the specific property, unique under the scope of the parent personnel class object.

Table 36: Attribute type PersonnelClassProperty.

RoleClass "Person" shall be used as specified in Table 37. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "Person" as a supported role class or role requirement. The (optional) relation to one or more personnel classes is realized by referencing these personnel classes as supported role classes. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	Person	
Description	Role class used for persons.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PersonnelModel/Person	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific person, within the scope of the information exchanged (e.g. production capability, production schedule, and production performance).
	name (type="xs:string")	The name of the individual.

Table 37: Role class Person.

User defined attributes for persons ("PersonProperty") shall be defined as complex attributes as specified in Table 38. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for persons. May be tested by the execution of a qualification test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/PersonnelModel/Person	
Attributes	id (type="xs:string")	An identification of the specific property.

Table 38: Attribute type PersonProperty.

RoleClass "QualificationTestSpecification" shall be used as specified in Table 39. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "QualificationTestSpecification" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

An external interface of type "TestConnector" has to be instantiated on a test specification and on a person or personnel class internal element; then, these external interfaces need to be interlinked. That way, the test specification is linked to that resource or resource type. If the test specification needs to specify a resource property or resource type property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "ts:" (cf. Clause 5.1).

Class Name	QualificationTestSpecification	
Description	Role class used for qualification test specifications.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PersonnelModel/QualificationTestSpecification	
Attributes (optional)	id (type="xs:string")	An identification of a test for certifying one or more values for one or more person properties.
	version (type="xs:string")	An identification of the version of the qualification test specification.

Table 39: Role class QualificationTestSpecification.

RoleClass "QualificationTestResult" shall be used as specified in Table 40. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "QualificationTestSpecification" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Usually, it represents a specific test result for a resource property. If the test result needs to specify such a resource property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "tr:" (cf. Clause 5.1).

Class Name	QualificationTestResult	
Description	Role class used for qualification test results.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PersonnelModel/QualificationTestResult	
Attributes (optional)	id (type="xs:string")	A unique instance identification that records the results from the execution of a test identified in a qualification test specification for a specific person.
	date (type="xs:dateTime")	The date and time of the qualification test.
	result (type="xs:string")	The result of the qualification test. The unit of measure of the associated test result, is to be specified as the "Unit" attribute, if applicable.
	expiration (type="xs:dateTime")	The date of the expiration of the qualification.

Table 40: Role class QualificationTestResult.

5.3.3 Equipment

RoleClass "EquipmentModel" shall be used as specified in Table 41. It is the base structuring role class for all equipment roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of EquipmentModel shall be used as a starting point for AML models.

Class Name	EquipmentModel
Description	Abstract role class used for structuring equipment roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/EquipmentModel
Attributes	None

Table 41: Role class EquipmentModel.

RoleClass "EquipmentClass" shall be used as specified in Table 42. Instances of this role class shall be realized as role classes, specifying "EquipmentClass" as parent class. Equipment class instances can be realized as internal elements following a singleton pattern, i.e., only up to one internal element can be created for each equipment class. This internal element can be used e.g., for linking within instance hierarchies, or for referencing external data. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	EquipmentClass	
Description	Role class used for equipment classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/EquipmentModel/EquipmentClass	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific equipment class, within the scope of the information exchanged (e.g. production capability, production schedule, production performance).
	equipmentLevel (type="xs:string")	An identification of the level in the role based equipment hierarchy. One of (nominal scaled constraint): "Enterprise", "Site", "Area", "Work Center", "Process Cell", "Production Unit", "Production Line", "Storage Zone", "Work Unit", "Unit", "Work Cell", "Storage Unit".

Table 42: Role class EquipmentClass.

User defined attributes for equipment classes ("EquipmentClassProperty") shall be defined as complex attributes as specified in Table 43. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for equipment classes. May be tested by the execution of an equipment capability test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/EquipmentModel/EquipmentClass	
Attributes	id (type="xs:string")	An identification of the specific property.

Table 43: Attribute type EquipmentClassProperty.

RoleClass "Equipment" shall be used as specified in Table 44. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "Equipment" as a supported role class or role requirement. The (optional) relation to one or more equipment classes is realized by referencing these classes as supported role classes. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	Equipment	
Description	Role class used for equipment.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/EquipmentModel/Equipment	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific piece of equipment, within the scope of the information exchanged (manufacturing operations definition, scheduling, capability and performance).
	equipmentLevel (type="xs:string")	An identification of the level in the role based equipment hierarchy. One of (nominal scaled constraint): "Enterprise", "Site", "Area", "Work Center", "Process Cell", "Production Unit", "Production Line", "Storage Zone", "Work Unit", "Unit", "Work Cell", "Storage Unit".

Table 44: Role class Equipment.

User defined attributes for equipment ("EquipmentProperty") shall be defined as complex attributes as specified in Table 45. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for equipment. May be tested by the execution of an equipment capability test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/EquipmentModel/Equipment	
Attributes	id (type="xs:string")	An identification of the specific property.

Table 45: Attribute type EquipmentProperty.

RoleClass "EquipmentCapabilityTestSpecification" shall be used as specified in Table 46. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "EquipmentCapabilityTestSpecification" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

An external interface of type "TestConnector" has to be instantiated on a test specification and on an equipment or equipment class internal element; then, these external interfaces need to be interlinked. That way, the test specification is linked to that resource or resource type. If the test specification needs to specify a resource property or resource type property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "ts:" (cf. Clause 5.1).

Class Name	EquipmentCapabilityTestSpecification	
Description	Role class used for equipment capability test specifications.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/EquipmentModel/ EquipmentCapabilityTestSpecification	
Attributes (optional)	id (type="xs:string")	An identification of a test for certifying one or more values for one or more equipment properties.
	version (type="xs:string")	An identification of the version of the capability test specification.

Table 46: Role class EquipmentCapabilityTestSpecification.

RoleClass "EquipmentCapabilityTestResult" shall be used as specified in Table 47. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "EquipmentCapabilityTestResult" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Usually, it represents a specific test result for a resource property. If the test result needs to specify such a resource property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "tr:" (cf. Clause 5.1).

Class Name	EquipmentCapabilityTestResult	
Description	Role class used for equipment capability test results.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/EquipmentModel/ EquipmentCapabilityTestResult	
Attributes (optional)	id (type="xs:string")	A unique instance identification that records the results from the execution of a test identified in a capability test specification for a specific piece of equipment.
	date (type="xs:dateTime")	The date and time of the capability test.
	result (type="xs:string")	The result of the capability test. The unit of measure of the associated test result, is to be specified as the "Unit" attribute, if applicable.
	expiration (type="xs:dateTime")	The date of the expiration of the capability.

Table 47: Role class EquipmentCapabilityTestResult.

5.3.4 Physical Asset

RoleClass "PhysicalAssetModel" shall be used as specified in Table 48. It is the base structuring role class for all physical asset roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of PhysicalAssetModel shall be used as a starting point for AML models.

Class Name	PhysicalAssetModel
Description	Abstract role class used for structuring physical asset roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel
Attributes	None

Table 48: Role class PhysicalAssetModel.

RoleClass "PhysicalAssetClass" shall be used as specified in Table 49. Instances of this role class shall be realized as system unit classes, specifying "PhysicalAssetClass" as a supported role class. Physical asset class instances can be realized as internal elements following a singleton pattern, i.e., only up to one internal element can be created for each physical asset class. This internal element can be used e.g., for linking within instance hierarchies. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PhysicalAssetClass	
Description	Role class used for physical asset classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAssetClass	
Attributes (optional)	manufacturer (type="xs:string")	An identification of the manufacturer.
	id (type="xs:string")	The manufacturer's identification of the specific physical asset class.
	description (type="xs:string")	Additional information about the physical asset class.

Table 49: Role class PhysicalAssetClass.

User defined attributes for physical asset classes ("PhysicalAssetClassProperty") shall be defined as complex attributes as specified in Table 50. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for physical asset classes. May be tested by the execution of a physical asset capability test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAssetClass	
Attributes	id (type="xs:string")	An identification of the specific property.

Table 50: Attribute type PhysicalAssetClassProperty.

RoleClass "PhysicalAsset" shall be used as specified in Table 51. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "PhysicalAsset" as a supported role class or role requirement. The relation to the physical asset class is realized by specifying the RefBaseSystemUnitPath with the path to the corresponding system unit class. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PhysicalAsset	
Description	Role class used for physical assets.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset	
Attributes (optional)	id (type="xs:string")	Defines a unique identification of a physical asset.
	physicalLocation (type="xs:string")	Actual physical location of the physical asset.
	fixedAssetId (type="xs:string")	Contains a unique identification for financial tracking as required by laws or regulations.
	vendorId (type="xs:string")	Contains a vendor's serial number.

Table 51: Role class PhysicalAsset.

User defined attributes for physical assets ("PhysicalAssetProperty") shall be defined as complex attributes as specified in Table 52. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for physical assets. May be tested by the execution of a physical asset capability test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset	
Attributes	id (type="xs:string")	An identification of the specific property.

Table 52: Attribute type PhysicalAssetProperty.

RoleClass "PhysicalAssetCapabilityTestSpecification" shall be used as specified in Table 53. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "PhysicalAssetCapabilityTestSpecification" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

An external interface of type "TestConnector" has to be instantiated on a test specification and on a physical asset or physical asset class internal element; then, these external interfaces need to be interlinked. That way, the test specification is linked to that resource or resource type. If the test specification needs to specify a resource property or resource type property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "ts:" (cf. Clause 5.1).

Class Name	PhysicalAssetCapabilityTestSpecification	
Description	Role class used for physical asset capability test specifications.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/ PhysicalAssetCapabilityTestSpecification	
Attributes (optional)	id (type="xs:string")	An identification of the specific physical asset capability test specification.
	version (type="xs:string")	An identification of the version of the capability test specification.

Table 53: Role class PhysicalAssetCapabilityTestSpecification.

RoleClass "PhysicalAssetCapabilityTestResult" shall be used as specified in Table 54. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "PhysicalAssetCapabilityTestResult" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Usually, it represents a specific test result for a resource property. If the test result needs to specify such a resource property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "tr:" (cf. Clause 5.1).

Class Name	PhysicalAssetCapabilityTestResult	
Description	Role class used for physical asset capability test results.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/ PhysicalAssetCapabilityTestResult	
Attributes (optional)	id (type="xs:string")	An identification of the specific physical asset capability test result.
	date (type="xs:dateTime")	The date and time of the capability test.
	result (type="xs:string")	The result of the capability test. The unit of measure of the associated test result, is to be specified as the "Unit" attribute, if applicable.
	expiration (type="xs:dateTime")	The date of the expiration of the capability.

Table 54: Role class PhysicalAssetCapabilityTestResult.

RoleClass "EquipmentAssetMapping" shall be used as specified in Table 55: an instance of this class is instantiated as an internal element somewhere in the instance hierarchy (could be realized in a dedicated *EquipmentAssetMapping* "folder"). The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

External interfaces of type "EquipmentAssetConnector" have to be instantiated on (i) an equipment and a physical asset and (ii) on an equipment asset mapping; then, these external interfaces need to be interlinked. That way, the physical asset is linked to an equipment through a reified equipment asset mapping relation (cf. Clause 5.1).

Class Name	EquipmentAssetMapping	
Description	RoleClass "EquipmentAssetMapping" shall be used to link physical assets to equipment.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/EquipmentAssetMapping	
Attributes (optional)	id (type="xs:string")	An identification of the specific equipment asset mapping.
	startTime (type="xs:dateTime")	The starting time of the association.
	endTime (type="xs:dateTime")	The ending time of the association.

Table 55: Role class EquipmentAssetMapping.

5.3.5   Material

RoleClass "MaterialModel" shall be used as specified in Table 56. It is the base structuring role class for all material roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of MaterialModel shall be used as a starting point for AML models.

Class Name	MaterialModel
Description	Abstract role class used for structuring material roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel
Attributes	None

Table 56: Role class MaterialModel.

RoleClass "MaterialClass" shall be used as specified in Table 57. Instances of this role class shall be realized as role classes, specifying "MaterialClass" as parent class. Material class instances can be realized as internal elements following a singleton pattern, i.e., only up to one internal element can be created for each material class. This internal element can be used e.g., for linking within instance hierarchies, or for referencing external data. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	MaterialClass	
Description	Role class used for material classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Product	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialClass	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific material class, within the scope of the information exchanged (e.g. production capability, production schedule, production performance)
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.

Table 57: Role class MaterialClass.

User defined attributes for material classes ("MaterialClassProperty") shall be defined as complex attributes as specified in Table 58. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for material classes. May be tested by the execution of a material test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialClass	
Attributes	id (type="xs:string")	An identification of a specific material class property.

Table 58: Attribute type MaterialClassProperty.

RoleClass "MaterialDefinition" shall be used as specified in Table 59. Instances of this role class shall be realized as system unit classes, specifying "MaterialDefinition" as a supported role class. The (optional) relation to one or more material classes is realized by referencing the material classes as supported role classes. Material definition instances can be realized as internal elements following a singleton pattern, i.e., only up to one internal element can be created for each material definition. This internal element can be used e.g., for linking within instance hierarchies. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	MaterialDefinition	
Description	Role class used for material definitions.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Product	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialDefinition	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific material definition, within the scope of the information exchanged (e.g. operations capability, operations schedule, operations performance).
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.

Table 59: Role class MaterialDefinition.

User defined attributes for material definitions ("MaterialDefinitionProperty") shall be defined as complex attributes as specified in Table 60. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for material definitions. May be tested by the execution of a material test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialDefinition	
Attributes	id (type="xs:string")	An identification of the specific material definition property.

Table 60: Attribute type MaterialDefinitionProperty.

RoleClass "MaterialLot" shall be used as specified in Table 61. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "MaterialLot" as a supported role class or role requirement. The relation to the material definition is realized by specifying the RefBaseSystemUnitPath pointing to the corresponding system unit class. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	MaterialLot	
Description	Role class used for material lots – a uniquely identified specific amount of material, either countable or weighable. A material lot describes the planned or actual total quantity or amount of material available, its current state, and its specific property values.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Product	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialLot	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific material lot, within the scope of the information exchanged (e.g. operations capability, operations schedule, operations performance).
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.
	status (type="xs:string")	Status of the material lot, e.g. "released", "approved", "blocked", "in process", "in quality check".
	storageLocation (type="xs:string")	An identification of the storage location or a physical location of the material lot.
	quantity (type="xs:string")	The quantity of the material lot. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 61: Role class MaterialLot.

<u>NOTE:</u> *If material lots are merged or absorbed (e.g. blended), then this is a new material lot [IEC 62264-2].*

NOTE: *Representation of non-lot controlled items (for example consumable materials or bulk materials), can be represented in the material lot model through the use of a unique ID for each different material definition [IEC 62264-2].*

NOTE: *If non-lot controlled items are maintained in multiple locations then the information can be represented in the material sublot model through the use of a unique sublot ID for each different location and material definition [IEC 62264-2].*

User defined attributes for material lots and sublots ("MaterialLotProperty") shall be defined as complex attributes as specified in Table 62. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the property.

Description	User defined attributes for material lots and sublots. May be tested by the execution of a material test specification.	
Host Class	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialLot - or - AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialSublot	
Attributes	id (type="xs:string")	An identification of the specific material lot property.

Table 62: Attribute type MaterialLotProperty.

RoleClass "MaterialSublot" shall be used as specified in Table 63. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "MaterialSublot" as a supported role class or role requirement. The relation to the parent material (sub)lot is realized by inserting the material sublot as a child element of a material (sub)lot internal element. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	MaterialSublot	
Description	Role class used for material sublots – a separately identifiable quantity of the same material lot. A material lot may be stored in separately identifiable quantities. All material sublots are part of the same material lot, so they have the material lot's property values. A material sublot may be just a single item.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Product	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialSublot	
Attributes (optional)	id (type="xs:string")	A unique identification of a specific material sublot, within the scope of the information exchanged (e.g. production capability, production schedule, production performance).
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.
	status (type="xs:string")	Status of the material sublot, e.g. "released", "approved", "blocked", "in process", "in quality check".
	storageLocation (type="xs:string")	An identification of the storage location or a physical location of the material sublot.
	quantity (type="xs:string")	The quantity of the material sublot. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 63: Role class MaterialSublot.

<u>NOTE:</u> *If material sublots are merged or absorbed (e.g. blended), then this is a new material sublot [IEC 62264-2].*

NOTE: Assemblies are collections or sets of related elements. Assemblies are represented as relationships between elements and attributes of the elements. Each assembly element has its own identity and properties, such as a material lot which has its own identity and properties. An object with an assembly (material lot, material sublot, material class, and material definition) shall contain the list of other elements that make up the assembly. Many assembly type industries, such as automobile manufacturing, airplane assembly, and furniture manufacturing use the concept of assemblies. A produced material, with a unique identification and properties, is made up of other materials with their own unique identification and properties [IEC 62264-2].

RoleClass "MaterialTestSpecification" shall be used as specified in Table 64. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "MaterialTestSpecification" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

An external interface of type "TestConnector" has to be instantiated on a test specification and on a material class, material definition, or material lot internal element; then, these external interfaces need to be interlinked. That way, the test specification is linked to that resource or resource type. If the test specification needs to specify a resource property or resource type property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "ts:" (cf. Clause 5.1).

Class Name	MaterialTestSpecification	
Description	Role class used for material test specifications.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialTestSpecification	
Attributes (optional)	id (type="xs:string")	An identification of a test for certifying one or more values for one or more material properties.
	version (type="xs:string")	An identification of the version of the maerial test specification.

Table 64: Role class MaterialTestSpecification.

RoleClass "MaterialTestResult" shall be used as specified in Table 65. It can be instantiated anywhere in the instance hierarchy as an internal element specifying "MaterialTestResult" as supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Usually, it represents a specific test result for a material lot property. If the test result needs to specify such a material lot property, it shall instantiate an attribute with the same name as the one to be referred, but prefixed with "tr:" (cf. Clause 5.1).

Class Name	MaterialTestResult	
Description	Role class used for material test results.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialTestResult	
Attributes (optional)	id (type="xs:string")	A unique instance identification that records the results from the execution of a test identified in a material test specification for a lot or sublot.
	date (type="xs:dateTime")	The date and time of the material test.
	result (type="xs:string")	The value or list of values returned from the performance of the material test. The unit of measure of the associated test result, is to be specified as the "Unit" attribute, if applicable.
	expiration (type="xs:dateTime")	The date of the expiration of the test results.

Table 65: Role class MaterialTestResult.

RoleClass "MaterialAssembly" shall be used as specified in Table 66. It holds internal elements of either material class, material definition, material lot, or material sublot type (often, but not exclusively, in terms of mirror objects). Instances of this role class shall be realized as a child internal element of the material type that defines an asembly, specifying "MaterialAssembly" as a supported role class or role requirement. A material assembly of a material class might only contain other material classes, a material definition assembly might only contain material definitions. A material assembly of a material lot or sublot might each contain instances of both material lots and material sublots.

The "MaterialAssembly" role class is also used to specify assembly relationships of the following entities: Material Segment Specification (cf. Clause 5.3.6), Material Specification and Operations Material Bill Item (cf. Clause 5.3.7), Material Requirement (cf. Clause 5.3.8), Material Actual (cf. Clause 5.3.9), and Material Capability (cf. Clause 5.3.10).

Class Name	MaterialAssembly
Description	Role class used for specifying material class and material definition assemblies.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialAssembly
Attributes	None

Table 66: Role class MaterialAssembly.

5.3.6   Process Segment

RoleClass "ProcessSegmentModel" shall be used as specified in Table 67. It is the base structuring role class for all process segment roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of ProcessSegmentModel shall be used as a starting point for AML models.

Class Name	ProcessSegmentModel
Description	Abstract role class used for structuring process segment roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel
Attributes	None

Table 67: Role class ProcessSegmentModel.

RoleClass "ProcessSegment" shall be used as specified in Table 68. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "ProcessSegment" as a supported role class or role requirement. Nested process segments can be modeled directly as child internal elements or they can be defined as child internal element in terms of a mirror object.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	ProcessSegment	
Description	Role class used for process segment classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ProcessSegment	
Attributes (optional)	id (type="xs:string")	A unique identification of a process segment, within the scope of the information exchanged (e.g. operations capability, operations schedule, operations performance).
	operationsType (type="xs:string")	Describes the category of the activity. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the activity contains several categories of process segments.
	duration (type="xs:decimal")	Duration of process segment, if known. The unit of measure of the duration, is to be specified as the "Unit" attribute, if defined.

Table 68: Role class ProcessSegment.

Parameters for process segments ("ProcessSegmentParameter") shall be defined as complex attributes as specified in Table 69. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the parameter.

Description	Process segment parameters for process segments.	
Host Class	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ProcessSegment	
Attributes	id (type="xs:string")	Identification of the process segment parameter.

Table 69: Attribute type ProcessSegmentParameter.

RoleClass "PersonnelSegmentSpecification" shall be used as specified in Table 70. Instances of this role class shall be realized as child internal elements of a "ProcessSegment" internal element in an instance hierarchy, specifying "PersonnelSegmentSpecification" as a supported role class or role requirement. Its purpose is the specification of the personnel class or person that is involved in the given process segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PersonnelSegmentSpecification	
Description	Role class used for personnel segment specification classes – personnel resources that are required for a process segment.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ PersonnelSegmentSpecification	
Attributes (optional)	personnelUse (type="xs:string")	Defines the expected use of the personnel class or person, e.g. "Allocated" or "Certified".
	quantity (type="xs:decimal")	Specifies the personnel resource required for the parent process segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 70: Role class PersonnelSegmentSpecification.

User defined attributes for personnel segment specifications ("PersonnelSegmentSpecificationProperty") shall be defined as complex attributes as specified in Table 71. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the resources required and its unit of measure, if applicable.

Description	User defined attributes for personnel segment specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ PersonnelSegmentSpecification	
Attributes	id (type="xs:string")	An identification of a property of the associated person property or personnel class property.
	quantity (type="xs:decimal")	Specifies the personnel resource required, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 71: Attribute type PersonnelSegmentSpecificationProperty.

RoleClass "EquipmentSegmentSpecification" shall be used as specified in Table 72. Instances of this role class shall be realized as child internal elements of a "ProcessSegment" internal element in an instance hierarchy, specifying "EquipmentSegmentSpecification" as a supported role class or role requirement. Its purpose is the specification of the equipment class or equipment that is involved in the given process segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	EquipmentSegmentSpecification	
Description	Role class used for equipment segment specification classes – equipment resources that are required for a process segment.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ EquipmentSegmentSpecification	
Attributes (optional)	equipmentUse (type="xs:string")	Defines the expected use of the equipment class or equipment in the context of the process segment, e.g. "Part Milling", "Remove Motor", "Run Test", and "Material Movement".
	quantity (type="xs:decimal")	Specifies the amount of resources required, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 72: Role class EquipmentSegmentSpecification.

User defined attributes for equipment segment specifications ("EquipmentSegmentSpecificationProperty") shall be defined as complex attributes as specified in Table 73. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the resources required and its unit of measure, if applicable.

Description	User defined attributes for equipment segment specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ EquipmentSegmentSpecification	
Attributes	id (type="xs:string")	An identification of a property of the associated equipment property or equipment class property.
	quantity (type="xs:decimal")	Specifies the amount of resources required. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 73: Attribute type EquipmentSegmentSpecificationProperty.

RoleClass "PhysicalAssetSegmentSpecification" shall be used as specified in Table 74. Instances of this role class shall be realized as child internal elements of a "ProcessSegment" internal element in an instance hierarchy, specifying "PhysicalAssetSegmentSpecification" as a supported role class or role requirement. Its purpose is the specification of the physical asset class or physical asset that is involved in the given process segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PhysicalAssetSegmentSpecification	
Description	Role class used for physical asset segment specification classes – physical asset resources that are required for a process segment.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ PhysicalAssetSegmentSpecification	
Attributes (optional)	physicalAssetUse (type="xs:string")	Defines the expected use of the physical asset class or physical asset in the context of the process segment.
	quantity (type="xs:decimal")	Specifies the amount of resources required, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 74: Role class PhysicalAssetSegmentSpecification.

User defined attributes for physical asset segment specifications ("PhysicalAssetSegmentSpecificationProperty") shall be defined as complex attributes as specified in Table 75. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the resources required and its unit of measure, if applicable.

Description	User defined attributes for physical asset segment specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ PhysicalAssetSegmentSpecification	
Attributes	id (type="xs:string")	An identification of a property of the associated physical asset property or physical asset class property.
	quantity (type="xs:decimal")	Specifies the amount of resources required. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 75: Attribute type PhysicalAssetSegmentSpecificationProperty.

RoleClass "MaterialSegmentSpecification" shall be used as specified in Table 76. Instances of this role class shall be realized as child internal elements of a "ProcessSegment" internal element in an instance hierarchy, specifying "MaterialSegmentSpecification" as a supported role class or role requirement. Its purpose is the specification of the material class or material definition that is involved in the given process segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	MaterialSegmentSpecification	
Description	Role class used for material segment specification classes – material resources that are required for a process segment.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ MaterialSegmentSpecification	
Attributes (optional)	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.
	materialUse (type="xs:string")	Defines the material use. One of (nominal scaled constraint): "Consumable", "Material Consumed", and "Material Produced".
	quantity (type="xs:decimal")	Specifies the amount of resources required. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 76: Role class MaterialSegmentSpecification.

User defined attributes for material segment specifications ("MaterialSegmentSpecificationProperty") shall be defined as complex attributes as specified in Table 77. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the resources required and its unit of measure, if applicable.

Description	User defined attributes for material segment specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ MaterialSegmentSpecification	
Attributes	id (type="xs:string")	An identification of a property of the associated material definition property or material class property.
	quantity (type="xs:decimal")	Specifies the amount of resources required, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 77: Attribute type MaterialSegmentSpecificationProperty.

RoleClass "ProcessSegmentDependency" shall be used as specified in Table 78. Its purpose is the specification of a process segment dependency that is relevant for the given process segment. Instances of this role class shall be realized as internal elements anywhere in the instance hierarchy, specifying "ProcessSegmentDependency" as a supported role class or role requirement. The referenced process segment is specified through internal linking, by adding an instance of interface class "DependencyConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "DependencyConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	ProcessSegmentDependency	
Description	Role class used for process segment dependency classes – process dependencies that are independent of any particular product or operations task.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ ProcessSegmentDependency	
Attributes (optional)	id (type="xs:string")	The identification of the unique instance of the process segment dependency.
	dependencyType (type="xs:string")	Defines the execution dependency constraints of one segment by another segment.
	dependencyFactor (type="xs:decimal")	Factor used by dependency. The unit of measure of the dependency factor, is to be specified as the "Unit" attribute, if defined.

Table 78: Role class ProcessSegmentDependency.

5.3.7 Operations Definition

RoleClass "OperationsDefinitionModel" shall be used as specified in Table 79. It is the base structuring role class for all operations definition roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of OperationsDefinitionModel shall be used as a starting point for AML models.

Class Name	OperationsDefinitionModel
Description	Abstract role class used for structuring operations definition roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel
Attributes	None

Table 79: Role class OperationsDefinitionModel.

RoleClass "OperationsDefinition" shall be used as specified in Table 80. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "OperationsDefinition" as a supported role class or role requirement. Operations definitions usually hold child internal elements of type "OperationsMaterialBill" and "OperationsSegment". The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsDefinition	
Description	Role class used for operations definition classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProcessStructure	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/OperationsDefinition	
Attributes (optional)	id (type="xs:string")	Uniquely identifies the operations definition.
	version (type="xs:string")	An identification of the version of the operations definition.
	operationsType (type="xs:string")	Describes the category of operation. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed".
		"Mixed" shall be used when the operations definition contains several types of operations requests and/or segment requirements.
	workDefinitionId (type="xs:string")	Identification of the external work definition associated with this operations definition.
	billOfResourceId (type="xs:string")	Identification of the external bill of resources associated with this operations definition.

Table 80: Role class OperationsDefinition.

RoleClass "OperationsMaterialBill" shall be used as specified in Table 81. Instances of this role class shall be realized as child internal elements of an "OperationsDefinition" internal element in an instance hierarchy, specifying "OperationsMaterialBill" as a supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	OperationsMaterialBill	
Description	Role class used for operations material bill classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ OperationsMaterialBill	
Attributes (optional)	id (type="xs:string")	Unique identification of a manufacturing bill.

Table 81: Role class OperationsMaterialBill.

RoleClass "OperationsMaterialBillItem" shall be used as specified in Table 82. Instances of this role class shall be realized as child internal elements of an "OperationsMaterialBill" internal element in an instance hierarchy, specifying "OperationsMaterialBillItem" as a supported role class or role requirement. Operations material bill items may be made up of further operations material bill items (often in terms of mirror child objects). In addition, an operations material bill item shall hold a mirror child internal element of type "MaterialSpecification" in order to specify the concrete material resource represented by this operations material bill item. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	OperationsMaterialBillItem	
Description	Role class used for operations material bill item classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ OperationsMaterialBillItem	
Attributes (optional)	id (type="xs:string")	Unique identification of a bill item.
	useType (type="xs:string")	Defines the use of the material. One of (nominal scaled constraint): "Consumed" or "Produced". Consumed: Indicates that bill items are all consumed materials. Produced: Indicates that bill items are all produced materials.
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.
	quantity (type="xs:decimal")	Specifies the amount of resources required. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 82: Role class OperationsMaterialBillItem.

RoleClass "OperationsSegment" shall be used as specified in Table 83. Instances of this role class shall be realized as child internal elements of an "OperationsDefinition" internal element in an instance hierarchy, specifying "OperationsSegment" as a supported role class or role requirement. Nested operations segments can be modeled directly as child internal elements or they can be defined as child internal element in terms of a mirror object. Usually, operations segment hold child internal elements for resource specification or of type "OperationsSegmentDependency". The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Related process segments are specified through internal linking, by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsSegment	
Description	Role class used for operations segment classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/OperationsSegment	
Attributes (optional)	id (type="xs:string")	Unique identification of a specific segment.
	duration (type="xs:string")	Duration of segment, if known. The unit of measure of the duration, is to be specified as the "Unit" attribute, if defined.
	operationsType (type="xs:string")	Describes the category of operation. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations segment contains several types of operations requests and/or segment requirements.
	workDefinitionId (type="xs:string")	Identification of the external work definition associated with this operations segment.

Table 83: Role class OperationsSegment.

Parameter specifications for operations segments ("ParameterSpecification") shall be defined as complex attributes as specified in Table 84. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the parameter.

Description	Parameter specification for operations segments.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/OperationsSegment	
Attributes	id (type="xs:string")	Identification of the parameter for a specific segment.

Table 84: Attribute type ParameterSpecification.

RoleClass "PersonnelSpecification" shall be used as specified in Table 85. Instances of this role class shall be realized as child internal elements of an "OperationsSegment" internal element in an instance hierarchy, specifying "PersonnelSpecification" as a supported role class or role requirement. Its purpose is the specification of the personnel class or person that is involved in the given operations segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PersonnelSpecification	
Description	Role class used for personnel specification classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ PersonnelSpecification	
Attributes (optional)	personnelUse (type="xs:string")	Defines the expected use of the personnel class or person.
	quantity (type="xs:decimal")	Specifies the amount of personnel resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 85: Role class PersonnelSpecification.

Properties for personnel specifications ("PersonnelSpecificationProperty") shall be defined as complex attributes as specified in Table 86. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Parameter specification for personnel specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ PersonnelSpecification	
Attributes	id (type="xs:string")	Identification of a property of the associated person property or personnel class property for a specific segment.
	quantity (type="xs:decimal")	Specifies the amount of personnel resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 86: Attribute type PersonnelSpecificationProperty.

RoleClass "EquipmentSpecification" shall be used as specified in Table 87. Instances of this role class shall be realized as child internal elements of an "OperationsSegment" internal element in an instance hierarchy, specifying "EquipmentSpecification" as a supported role class or role requirement. Its purpose is the specification of the equipment class or equipment that is involved in the given operations segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	EquipmentSpecification	
Description	Role class used for equipment specification classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ EquipmentSpecification	
Attributes (optional)	equipmentUse (type="xs:string")	Defines the expected use of the equipment class or equipment.
	quantity (type="xs:decimal")	Specifies the amount of equipment resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 87: Role class EquipmentSpecification.

Properties for equipment specifications ("EquipmentSpecificationProperty") shall be defined as complex attributes as specified in Table 88. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Parameter specification for equipment specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ EquipmentSpecification	
Attributes	id (type="xs:string")	Identification of a property of the associated equipment property or equipment class property for a specific segment.
	quantity (type="xs:decimal")	Specifies the amount of equipment resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 88: Attribute type EquipmentSpecificationProperty.

RoleClass "PhysicalAssetSpecification" shall be used as specified in Table 89. Instances of this role class shall be realized as child internal elements of an "OperationsSegment" internal element in an instance hierarchy, specifying "PhysicalAssetSpecification" as a supported role class or role requirement. Its purpose is the specification of the physical asset class or physical asset that is involved in the given operations segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

Class Name	PhysicalAssetSpecification	
Description	Role class used for physical asset specification classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ PhysicalAssetSpecification	
Attributes (optional)	physicalAssetUse (type="xs:string")	Defines the expected use of the physical asset class or physical asset.
	quantity (type="xs:decimal")	Specifies the amount of physical asset resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 89: Role class PhysicalAssetSpecification.

Properties for physical asset specifications ("PhysicalAssetSpecificationProperty") shall be defined as complex attributes as specified in Table 90. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Parameter specification for physical asset specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ PhysicalAssetSpecification	
Attributes	id (type="xs:string")	Identification of a property of the associated physical asset property or physical asset class property for a specific segment.
	quantity (type="xs:decimal")	Specifies the amount of physical asset resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 90: Attribute type PhysicalAssetSpecificationProperty.

RoleClass "MaterialSpecification" shall be used as specified in Table 91. Instances of this role class shall be realized as child internal elements of an "OperationsSegment" internal element in an instance hierarchy, specifying "MaterialSpecification" as a supported role class or role requirement. Its purpose is the specification of the material class or material definition that is involved in the given operations segment. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: Typically, either a material class or material definition is specified [IEC 62264-2].

Class Name	MaterialSpecification	
Description	Role class used for material specification classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ MaterialSpecification	
Attributes (optional)	materialUse (type="xs:string")	Defines the expected material use. One of (nominal scaled constraint) "Material Consumed", "Material Produced", or "Consumable".
	quantity (type="xs:decimal")	Specifies the amount of material resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.

Table 91: Role class MaterialSpecification.

Properties for material specifications ("MaterialSpecificationProperty") shall be defined as complex attributes as specified in Table 92. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Parameter specification for material specifications.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ MaterialSpecification	
Attributes	id (type="xs:string")	Identification of the associated material property for a specific segment.
	quantity (type="xs:decimal")	Specifies the amount of material resources required for the parent segment, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 92: Attribute type MaterialSpecificationProperty.

RoleClass "OperationsSegmentDependency" shall be used as specified in Table 93. Instances of this role class shall be realized as child internal elements of an "OperationsSegment" internal element in an instance hierarchy, specifying "OperationsSegmentDependency" as a supported role class or role requirement. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The referenced operations segment is specified through internal linking, by adding an instance of interface class "DependencyConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "DependencyConnector" is already existing, it can be reused.

Class Name	OperationsSegmentDependency	
Description	Role class used for operations segment dependency classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsDefinitionModel/ OperationsSegmentDependency	
Attributes (optional)	id (type="xs:string")	Identification of the unique instance of the operations segment dependency.
	dependencyType (type="xs:string")	Defines the execution dependency constraints of one segment by another segment.
	dependencyFactor (type="xs:string")	Factor used by dependency. The unit of measure of the dependency factor, is to be specified as the "Unit" attribute, if defined.

Table 93: Role class OperationsSegmentDependency.

5.3.8   Operations Schedule

RoleClass "OperationsScheduleModel" shall be used as specified in Table 94. It is the base structuring role class for all operations schedule roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of OperationsScheduleModel shall be used as a starting point for AML models.

Class Name	OperationsScheduleModel
Description	Abstract role class used for structuring operations schedule roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel
Attributes	None

Table 94: Role class OperationsScheduleModel.

RoleClass "OperationsSchedule" shall be used as specified in Table 95. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "OperationsSchedule" as a supported role class or role requirement. Child internal elements include mainly elements of type "OperationsRequest". The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsSchedule	
Description	Role class used for operations schedule classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProcessStructure	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ OperationsSchedule	
Attributes (optional)	id (type="xs:string")	Uniquely identifies the operations schedule and could include version and revision identification.
	operationsType (type="xs:string")	Describes the category of operation. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations definition contains several types of operations requests and/or segment requirements.
	startTime (type="xs:dateTime")	The starting time for the associated operations schedule, if applicable.
	endTime (type="xs:dateTime")	The ending time for the associated operations schedule, if applicable.
	publishedDate (type="xs:dateTime")	The date and time on which the operations schedule was published or generated.
	scheduledState (type="xs:string")	Indicates the state of the operations schedule. One of (nominal scaled constraint) "Forecast" or "Released". Forecast: the requirements have not been released for use. Released: the requirements have been released for use.

Table 95: Role class OperationsSchedule.

RoleClass "OperationsRequest" shall be used as specified in Table 96. Instances of this role class shall be realized as child internal elements of an "OperationsSchedule" internal element in an instance hierarchy, specifying "OperationsRequest" as a supported role class or role requirement. Operations requests usually hold child internal elements of type "SegmentRequirement". The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

A related operations definition is specified through internal linking, by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsRequest	
Description	Role class used for operations request classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProcessStructure	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/OperationsRequest	
Attributes (optional)	id (type="xs:string")	Unique identification of the operations request.
	operationsType (type="xs:string")	Describes the category of operations. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations definition contains several types of operations requests and/or segment requirements.
	startTime (type="xs:dateTime")	When operation is to be started operations schedule, if applicable.
	endTime (type="xs:dateTime")	When operation is to be completed, if applicable.
	priority (type="xs:string")	The priority of the request, if applicable.
	requestState (type="xs:string")	Indicates the state of the operations request. One of (nominal scaled constraint) "Forecast" or "Released". Forecast: the requirements have not been released for use. Released: the requirements have been released for use.

Table 96: Role class OperationsRequest.

RoleClass "SegmentRequirement" shall be used as specified in Table 97. Instances of this role class shall be realized as child internal elements of an "OperationsRequest" internal element in an instance hierarchy, specifying "SegmentRequirement" as a supported role class or role requirement. Nested segment requirements can be modeled directly as child internal elements or they can be defined as child internal element in terms of a mirror object. Typical child internal elements of segment requirements are the resource requirement classes specified below. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

A related operations segment or process segment is specified through internal linking, by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	SegmentRequirement	
Description	Role class used for segment requirement classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ SegmentRequirement	
Attributes (optional)	id (type="xs:string")	Unique identification of the segment requirement.
	operationsType (type="xs:string")	Describes the category of operation. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations definition contains several types of operations requests and/or segment requirements.
	earliestStartTime (type="xs:dateTime")	The expected earliest start time of this segment requirement, if applicable.
	latestEndTime (type="xs:dateTime")	The expected latest ending time of this segment requirement, if applicable.
	duration (type="xs:decimal")	The expected duration of this segment requirement, if applicable. Note: this should match the associated segment duration. The unit of measure of the duration, is to be specified as the "Unit" attribute, if applicable.
	segmentState (type="xs:string")	Indicates the state of the segment request. One of (nominal scaled constraint) "Forecast" or "Released". Forecast: the requirements have not been released for use. Released: the requirements have been released for use.

Table 97: Role class SegmentRequirement.

Parameters for segment requirements ("SegmentParameter") shall be defined as complex attributes as specified in Table 98. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the parameter.

Description	Parameter specification for segment requirements.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ SegmentRequirement	
Attributes	id (type="xs:string")	Identification of the segment parameter.

Table 98: Attribute type SegmentParameter.

RoleClass "PersonnelRequirement" shall be used as specified in Table 99. Instances of this role class shall be realized as child internal elements of a "SegmentRequirement" internal element in an instance hierarchy, specifying "PersonnelRequirement" as a supported role class or role requirement. Its purpose is the specification of the personnel class or person that is involved in the given segment requirement. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: Typically, either personnel class or person is specified, but not both [IEC 62264-2].

Class Name	PersonnelRequirement	
Description	Role class used for personnel requirement classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ PersonnelRequirement	
Attributes (optional)	personnelUse (type="xs:string")	Defines the expected use of the personnel class or person.
	quantity (type="xs:decimal")	Specifies the amount of personnel resources required for the parent segment, if applicable. Applies to each member of the person and personnel class sets. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 99: Role class PersonnelRequirement.

Properties for personnel requirements ("PersonnelRequirementProperty") shall be defined as complex attributes as specified in Table 100. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for personnel requirements.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationScheduleModel/ PersonnelRequirement	
Attributes	id (type="xs:string")	Identification of the associated person property or personnel class property for a specific segment requirement.
	quantity (type="xs:decimal")	Specifies the amount of the property required for the parent personnel requirement, if applicable. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 100: Attribute type PersonnelRequirementProperty.

RoleClass "EquipmentRequirement" shall be used as specified in Table 101. Instances of this role class shall be realized as child internal elements of a "SegmentRequirement" internal element in an instance hierarchy, specifying "EquipmentRequirement" as a supported role class or role requirement. Its purpose is the specification of the equipment class or equipment that is involved in the given segment requirement. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: *Typically, either equipment class or equipment is specified, but not both [IEC 62264-2].*

Class Name	EquipmentRequirement	
Description	Role class used for equipment requirement classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationScheduleModel/ EquipmentRequirement	
Attributes (optional)	equipmentUse (type="xs:string")	Defines the expected use of the equipment class or equipment.
	quantity (type="xs:decimal")	Specifies the amount of equipment resources required for the parent segment, if applicable. Applies to each member of the equipment and equipment class sets. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.
	equipmentLevel (type="xs:string")	A definition of the level of the associated element of the equipment model.

Table 101: Role class EquipmentRequirement.

Properties for equipment requirements ("EquipmentRequirementProperty") shall be defined as complex attributes as specified in Table 102. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for equipment requirements.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ EquipmentRequirement	
Attributes	id (type="xs:string")	Identification of the associated equipment property or equipment class property for a specific segment requirement.
	quantity (type="xs:decimal")	Specifies the amount of equipment property required for the parent equipment requirement, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 102: Attribute type EquipmentRequirementProperty.

RoleClass "PhysicalAssetRequirement" shall be used as specified in Table 103. Instances of this role class shall be realized as child internal elements of a "SegmentRequirement" internal element in an instance hierarchy, specifying "PhysicalAssetRequirement" as a supported role class or role requirement. Its purpose is the specification of the physical asset class or physical asset that is involved in the given segment requirement. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

<u>NOTE:</u> *Typically, either physical asset class or physical asset is specified, but not both [IEC 62264-2].*

Class Name	PhysicalAssetRequirement	
Description	Role class used for physical asset requirement classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ PhysicalAssetRequirement	
Attributes (optional)	physicalAssetUse (type="xs:string")	Defines the expected use of the physical asset class or physical asset.
	quantity (type="xs:decimal")	Specifies the amount of physical asset resources required for the parent segment, if applicable. Applies to each member of the physical asset and physical asset class sets. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.
	equipmentLevel (type="xs:string")	A level definition for the associated element in the hierarchy of the physical asset model.

Table 103: Role class PhysicalAssetRequirement.

Properties for physical asset requirements ("PhysicalAssetRequirementProperty") shall be defined as complex attributes as specified in Table 104. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for physical asset requirements.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ PhysicalAssetRequirement	
Attributes	id (type="xs:string")	Identification of the associated physical asset property or physical asset class property for a specific segment requirement.
	quantity (type="xs:decimal")	Specifies the amount of physical asset property required for the parent physical asset requirement, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 104: Attribute type PhysicalAssetRequirementProperty.

RoleClass "MaterialRequirement" shall be used as specified in Table 105. Instances of this role class shall be realized as child internal elements of a "SegmentRequirement" internal element in an instance hierarchy, specifying "MaterialRequirement" as a supported role class or role requirement. Its purpose is the specification of the material class, material definition, material lot, or material sublot that is involved in the given segment requirement. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: Typically, either material class, material definition, material lot, or material sublot is specified [IEC 62264-2].

NOTE: If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot [IEC 62264-2].

Class Name	MaterialRequirement	
Description	Role class used for material requirement classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ MaterialRequirement	
Attributes (optional)	materialUse (type="xs:string")	Identifies the use of the material.
	storageLocation (type="xs:string")	Identifies the proposed location of the material, if applicable.
	quantity (type="xs:decimal")	Specifies the amount of material to be used, if applicable. Applies to each member of the material lot, material definition, or material class sets. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.

Table 105: Role class MaterialRequirement.

Properties for material requirements ("MaterialRequirementProperty") shall be defined as complex attributes as specified in Table 106. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for material requirements.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ MaterialRequirement	
Attributes	id (type="xs:string")	Identification of a property of the associated material definition property or material class property for a specific segment requirement.
	quantity (type="xs:decimal")	Specifies the amount of material to be produced, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 106: Attribute type MaterialRequirementProperty.

RoleClass "RequestedSegmentResponse" shall be used as specified in Table 107. Instances of this role class shall be realized as child internal elements of an "OperationsRequest" internal element in an instance hierarchy, specifying "RequestedSegmentResponse" as a supported role class or role requirement. Requested segment responses may hold a child internal element (typically a mirror element) of type "ProcessSegment" specifying the corresponding process segment. The same concept applies to associated elements of type "OperationsDefinition".

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	RequestedSegmentResponse	
Description	Role class used for requested segment response classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsScheduleModel/ RequestedSegmentResponse	
Attributes (optional)	id (type="xs:string")	Uniquely identifies the instance of a process segment executed.
	operationsType (type="xs:string")	Describes the category of operations. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations response contains several categories of segment responses.
	actualStartTime (type="xs:dateTime")	The actual start time of this segment response.
	actualEndTime (type="xs:dateTime")	The actual end time of this segment response.
	segmentState (type="xs:string")	

Table 107: Role class RequestedSegmentResponse.

5.3.9 Operations Performance

RoleClass "OperationsPerformanceModel" shall be used as specified in Table 108. It is the base structuring role class for all operations performance roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of OperationsPerformanceModel shall be used as a starting point for AML models.

Class Name	OperationsPerformanceModel
Description	Abstract role class used for structuring operations performance roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel
Attributes	None

Table 108: Role class OperationsPerformanceModel.

RoleClass "OperationsPerformance" shall be used as specified in Table 109. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "OperationsPerformance" as a supported role class or role requirement. An element of type "OperationsPerformance" may define a child internal element of type "OperationsSchedule" (typically as mirror object) in orer to relate the associated operations schedule. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsPerformance	
Description	Role class used for operations performance classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProcessStructure	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ OperationsPerformance	
Attributes (optional)	id (type="xs:string")	Uniquely identifies the operations performance and could include version and revision identification.
	operationsType (type="xs:string")	Describes the category of operation. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations performance contains several categories of operations responses and/or segment responses.
	startTime (type="xs:dateTime")	The starting time for the associated operations performance, if applicable.
	endTime (type="xs:dateTime")	The ending time for the associated operations performance, if applicable.
	performanceState (type="xs:string")	Indicates the state of the operations performance. One of (nominal scaled constraint) "Ready", "Completed", "Aborted", or "Holding".
	publishedDate (type="xs:dateTime")	The date and time on which the operations performance was published or generated.

Table 109: Role class OperationsPerformance.

RoleClass "OperationsResponse" shall be used as specified in Table 110. Instances of this role class shall be realized as child internal elements of an "OperationsPerformance" internal element in an instance hierarchy, specifying "OperationsResponse" as a supported role class or role requirement. An operations response typically holds child elements of type "SegmentResponse". The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

A related operations request or operations definition is specified through internal linking, by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsResponse	
Description	Role class used for operations response classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProcessStructure	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/OperationsResponse	
Attributes (optional)	id (type="xs:string")	Uniquely identifies the operations response.
	operationsType (type="xs:string")	Describes the category of operation. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations response contains several categories of segment responses.
	startTime (type="xs:dateTime")	The starting time of this operations response.
	endTime (type="xs:dateTime")	The ending time of this operations response.
	responseState (type="xs:string")	Indicates the state of the operations response. One of (nominal scaled constraint) "Ready", "Completed", "Aborted", or "Holding".

Table 110: Role class OperationsResponse.

RoleClass "SegmentResponse" shall be used as specified in Table 111. Instances of this role class shall be realized as child internal elements of an "OperationsResponse" internal element in an instance hierarchy, specifying "SegmentResponse" as a supported role class or role requirement. Nested segment responses can be modeled directly as child internal elements or they can be defined as child internal element in terms of a mirror object. The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

A related segment requirement, operations segment or process segment is specified through internal linking, by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

NOTE: The same process segment can be referenced multiple times in a segment response [IEC 62264-2].

Class Name	SegmentResponse	
Description	Role class used for segment response classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ SegmentResponse	
Attributes (optional)	id (type="xs:string")	Uniquely identifies the instance of a process segment executed.
	operationsType (type="xs:string")	Describes the category of operations. One of (nominal scaled constraint) "Production", "Maintenance", "Quality", "Inventory", or "Mixed". "Mixed" shall be used when the operations response contains several categories of segment responses.
	actualStartTime (type="xs:dateTime")	The actual start time of this segment response.
	actualEndTime (type="xs:dateTime")	The actual end time of this segment response.
	segmentState (type="xs:string")	Indicates the state of the segment response. One of (nominal scaled constraint) "Ready", "Completed", "Aborted", or "Holding".

Table 111: Role class SegmentResponse.

Data for segment responses ("SegmentData") shall be defined as complex attributes as specified in Table 112. The top-level attribute holds the description, the value and its unit of measure, if applicable. A sub-attribute holds the IEC 62264 ID of the data.

Description	Data specification for segment responses.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ SegmentResponse	
Attributes (optional)	id (type="xs:string")	Identification of the segment data.

Table 112: Attribute type SegmentData.

RoleClass "PersonnelActual" shall be used as specified in Table 112. Instances of this role class shall be realized as child internal elements of a "SegmentResponse" internal element in an instance hierarchy, specifying "PersonnelActual" as a supported role class or role requirement. Its purpose is the specification of the personnel class or person that is involved in the given segment response. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: *Typically, either personnel class or person is specified, but not both [IEC 62264-2].*

Class Name	PersonnelActual	
Description	Role class used for personnel actual classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/PersonnelActual	
Attributes (optional)	personnelUse (type="xs:string")	Defines the actual use of the personnel class or person.
	quantity (type="xs:decimal")	Specifies the amount of personnel resources used in the parent segment, if applicable. Applies to each member of the person or personnel class sets. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 113: Role class PersonnelActual.

Properties for personnel actuals ("PersonnelActualProperty") shall be defined as complex attributes as specified in Table 114. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for personnel actuals.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/PersonnelActual	
Attributes	id (type="xs:string")	Identification of the associated person property or personnel class property for a specific segment response.
	quantity (type="xs:decimal")	Specifies the amount of personnel resources used in the parent segment, if applicable. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 114: Attribute type PersonnelActualProperty.

RoleClass "EquipmentActual" shall be used as specified in Table 115. Instances of this role class shall be realized as child internal elements of a "SegmentResponse" internal element in an instance hierarchy, specifying "EquipmentActual" as a supported role class or role requirement. Its purpose is the specification of the equipment class or equipment that is involved in the given segment response. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: Typically, either equipment class or equipment is specified, but not both [IEC 62264-2].

Class Name	EquipmentActual	
Description	Role class used for equipment actual classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ EquipmentActual	
Attributes (optional)	equipmentUse (type="xs:string")	Defines the actual use of the equipment class or equipment.
	quantity (type="xs:decimal")	Specifies the amount of equipment resources used in the parent segment, if applicable. Applies to each member of the equipment or equipment class sets. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 115: Role class EquipmentActual.

Properties for equipment actuals ("EquipmentActualProperty") shall be defined as complex attributes as specified in Table 116. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for equipment actuals.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ EquipmentActual	
Attributes	id (type="xs:string")	Identification of the associated equipment property or equipment class property for a specific segment response.
	quantity (type="xs:decimal")	Specifies the amount of equipment resources used in the parent segment, if applicable. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 116: Attribute type EquipmentActualProperty.

RoleClass "PhysicalAssetActual" shall be used as specified in Table 117. Instances of this role class shall be realized as child internal elements of a "SegmentResponse" internal element in an instance hierarchy, specifying "PhysicalAssetActual" as a supported role class or role requirement. Its purpose is the specification of the physical asset class or physical asset that is involved in the given segment response. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: _Typically, either physical asset class or physical asset is specified, but not both [IEC 62264-2]._

Class Name	PhysicalAssetActual	
Description	Role class used for physical asset actual classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ PhysicalAssetActual	
Attributes (optional)	physicalAssetUse (type="xs:string")	Defines the actual use of the physical asset class or physical asset. Example for maintenance: Repaired, Removed, Replacement, Calibrated, Modified/Improved.
	quantity (type="xs:decimal")	Specifies the amount of physical asset resources used in the parent segment, if applicable. Applies to each member of the physical asset or physical asset class sets. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 117: Role class PhysicalAssetActual.

Properties for physical asset actuals ("PhysicalAssetActualProperty") shall be defined as complex attributes as specified in Table 118. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for physical asset actuals.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/ PhysicalAssetActual	
Attributes	id (type="xs:string")	Identification of the associated physical asset property or physical asset class property for a specific segment response.
	quantity (type="xs:decimal")	Specifies the amount of physical asset resources used in the parent segment, if applicable. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 118: Attribute type PhysicalAssetActualProperty.

RoleClass "MaterialActual" shall be used as specified in Table 119. Instances of this role class shall be realized as child internal elements of a "SegmentResponse" internal element in an instance hierarchy, specifying "MaterialActual" as a supported role class or role requirement. Its purpose is the specification of the material class, material definition, material lot, or material sublot that is involved in the given segment response. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

NOTE: Typically, either a material class, material definition, material lot, or material sublot is specified [IEC 62264-2].

Class Name	MaterialActual
Description	Role class used for material actual classes.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/MaterialActual
Attributes (optional)	materialUse (type="xs:string")	Defines the actual use of the material. One of (nominal scaled constraint) "Consumable", "Consumed", "Produced", "Replaced Asset", "Replacement Asset", "Sample", "Returned Sample", "Carrier", "Returned Carrier". Defined values for production operations: Consumable, Consumed, Produced. Defined values for maintenance operations: Consumable, Replaced Asset, Replacement Asset. Defined values for quality operations: Consumable, Sample, Returned Sample. Defined values for inventory operations: Consumable, Carrier, Returned Carrier.
	storageLocation (type="xs:string")	Identifies the actual location of the produced material, if applicable.
	quantity (type="xs:decimal")	Specifies the amount of material produced by the parent segment. Applies to each member of the material lot, material definition, or material class sets. The unit of measure of the quantity, is to be spec. as the "Unit" attribute, if applicable.
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: components of the assembly are physically connected or in the same area. Logical: components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.

Table 119: Role class MaterialActual.

Properties for material actuals ("MaterialActualProperty") shall be defined as complex attributes as specified in Table 120. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for material actuals.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsPerformanceModel/MaterialActual	
Attributes	id (type="xs:string")	Identification of the associated material definition property or material class property for a specific segment response.
	quantity (type="xs:decimal")	Specifies the amount of material produced by the parent segment. Applies to each member of the material lot, material definition, or material class sets. The unit of measure of the quantity, is to be specified as the "Unit" attribute, if applicable.

Table 120: Attribute type MaterialActualProperty.

5.3.10 Operations Capability

RoleClass "OperationsCapabilityModel" shall be used as specified in Table 121. It is the base structuring role class for all operations capability roles. In the context of IEC 62264, one of the concrete child roles (or any user defined sub role thereof) of OperationsCapabilityModel shall be used as a starting point for AML models.

Class Name	OperationsCapabilityModel
Description	Abstract role class used for structuring operations capability roles.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel
Attributes	None

Table 121: Role class OperationsCapabilityModel.

RoleClass "OperationsCapability" shall be used as specified in Table 122. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "OperationsCapability" as a supported role class or role requirement. Besides the entities specified below, also entities of type "ProcessSegmentCapability" might be added to an operations capability by means of a child internal element (be it explicitly modeled or a mirror object). The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	OperationsCapability	
Description	Role class used for operations capability classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ OperationsCapability	
Attributes (optional)	id (type="xs:string")	Defines a unique instance of an operations capability for a specified element of the equipment hierarchy model (enterprise, site, area, work center, or work unit).
	capacityType (type="xs:string")	The capacity type. One of (nominal scaled constraint) "Used", "Unused", "Total", "Available", "Unattainable", or "Committed".
	reason (type="xs:string")	Defines the reason for the capability type.
	confidenceFactor (type="xs:string")	A measure of the confidence of the capacity value.
	startTime (type="xs:dateTime")	The starting date and time of the operations capability.
	endTime (type="xs:dateTime")	The ending date and time of the operations capability.
	publishedDate (type="xs:dateTime")	The date and time on which the operations capability was published or generated.

Table 122: Role class OperationsCapability.

RoleClass "PersonnelCapability" shall be used as specified in Table 123. Instances of this role class shall be realized as child internal elements of an "OperationsCapability" or a "ProcessSegmentCapability" internal element in an instance hierarchy, specifying "PersonnelCapability" as a supported role class or role requirement. Its purpose is the specification of the personnel class or person that is involved in the given operations capability or process segment capability. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	PersonnelCapability	
Description	Role class used for personnel capability classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ PersonnelCapability	
Attributes (optional)	capabilityType (type="xs:string")	The capability type. One of (nominal scaled constraint) "Used", "Unused", "Total", "Available", "Unattainable", or "Committed".
	reason (type="xs:string")	Defines the reason for the capability type.
	confidenceFactor (type="xs:string")	A measure of the confidence of the capacity value.
	personnelUse (type="xs:string")	Defines the expected capability use of the personnel class or person.
	startTime (type="xs:dateTime")	The starting time associated with the personnel capability.
	endTime (type="xs:dateTime")	The ending time associated with the personnel capability.
	quantity (type="xs:decimal")	Specifies the quantity of the personnel capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 123: Role class PersonnelCapability.

Properties for personnel capabilities ("PersonnelCapabilityProperty") shall be defined as complex attributes as specified in Table 124. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for personnel capabilities.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ PersonnelCapability	
Attributes	id (type="xs:string")	Identification of the associated person property or personnel class property.
	quantity (type="xs:decimal")	Specifies the quantity of the personnel capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 124: Attribute type PersonnelCapabilityProperty.

RoleClass "EquipmentCapability" shall be used as specified in Table 125. Instances of this role class shall be realized as child internal elements of an "OperationsCapability" or a "ProcessSegmentCapability" internal element in an instance hierarchy, specifying "EquipmentCapability" as a supported role class or role requirement. Its purpose is the specification of the equipment class or equipment that is involved in the given operations capability or process segment capability. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	EquipmentCapability	
Description	Role class used for equipment capability classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ EquipmentCapability	
Attributes (optional)	capabilityType (type="xs:string")	The capability type. One of (nominal scaled constraint) "Used", "Unused", "Total", "Available", "Unattainable", or "Committed".
	reason (type="xs:string")	Defines the reason for the capability type.
	confidenceFactor (type="xs:string")	A measure of the confidence of the capacity value.
	equipmentUse (type="xs:string")	Defines the expected capability use of the equipment class or equipment.
	startTime (type="xs:dateTime")	The starting time associated with the equipment capability.
	endTime (type="xs:dateTime")	The ending time associated with the equipment capability.
	quantity (type="xs:decimal")	Specifies the quantity of the equipment capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 125: Role class EquipmentCapability.

Properties for equipment capabilities ("EquipmentCapabilityProperty") shall be defined as complex attributes as specified in Table 126. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for equipment capabilities.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ EquipmentCapability	
Attributes	id (type="xs:string")	Identification of the associated equipment property or equipment class property.
	quantity (type="xs:decimal")	Specifies the quantity of the equipment capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 126: Attribute type EquipmentCapabilityProperty.

RoleClass "PhysicalAssetCapability" shall be used as specified in Table 127. Instances of this role class shall be realized as child internal elements of an "OperationsCapability" or a "ProcessSegmentCapability" internal element in an instance hierarchy, specifying "PhysicalAssetCapability" as a supported role class or role requirement. Its purpose is the specification of the physical asset class or physical asset that is involved in the given operations capability or process segment capability. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	PhysicalAssetCapability	
Description	Role class used for physical asset capability classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ PhysicalAssetCapability	
Attributes (optional)	capabilityType (type="xs:string")	The capability type. One of (nominal scaled constraint) "Used", "Unused", "Total", "Available", "Unattainable", or "Committed".
	reason (type="xs:string")	Defines the reason for the capability type.
	confidenceFactor (type="xs:string")	A measure of the confidence of the capacity value.
	physicalAssetUse (type="xs:string")	Defines the expected capability use of the physical asset class or physical asset.
	startTime (type="xs:dateTime")	The starting time associated with the physical asset capability.
	endTime (type="xs:dateTime")	The ending time associated with the physical asset capability.
	quantity (type="xs:decimal")	Specifies the quantity of the physical asset capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 127: Role class PhysicalAssetCapability.

Properties for physical asset capabilities ("PhysicalAssetCapabilityProperty") shall be defined as complex attributes as specified in Table 128. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for physical asset capabilities.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/ PhysicalAssetCapability	
Attributes	id (type="xs:string")	Identification of the associated physical asset property or physical asset class property.
	quantity (type="xs:decimal")	Specifies the quantity of the physical asset capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 128: Attribute type PhysicalAssetCapabilityProperty.

RoleClass "MaterialCapability" shall be used as specified in Table 129. Instances of this role class shall be realized as child internal elements of an "OperationsCapability" or a "ProcessSegmentCapability" internal element in an instance hierarchy, specifying "MaterialCapability" as a supported role class or role requirement. Its purpose is the specification of the material class, material definition, material lot, or material sublot that is involved in the given operations capability or process segment capability. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

Class Name	MaterialCapability
Description	Role class used for material capability classes.
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for Element Reference	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/MaterialCapability
Attributes (optional)	capabilityType (type="xs:string")	The capability type. One of (nominal scaled constraint) "Used", "Unused", "Total", "Available", "Unattainable", or "Committed".
	reason (type="xs:string")	Defines the reason for the capability type.
	confidenceFactor (type="xs:string")	A measure of the confidence of the capacity value.
	materialUse (type="xs:string")	Defines the expected capability use of the material.
	startTime (type="xs:dateTime")	The starting time associated with the material capability.
	endTime (type="xs:dateTime")	The ending time associated with the material capability.
	quantity (type="xs:decimal")	Specifies the quantity of the material capability defined, if applicable. The unit of measure of the material quantity, is to be specified as the "Unit" attribute, if applicable.
	assemblyType (type="xs:string")	Defines the type of the assembly. One of (nominal scaled constraint) "Physical" or "Logical". Physical: the components of the assembly are physically connected or in the same area. Logical: the components of the assembly are not necessarily physically connected or in the same area.
	assemblyRelationship (type="xs:string")	Defines the type of the relationships. One of (nominal scaled constraint) "Permanent" or "Transient". Permanent: an assembly that is not intended to be split during the production process. Transient: a temporary assembly used during production, such as a pallet of different materials or a batch kit.

Table 129: Role class MaterialCapability.

Properties for material capabilities ("MaterialCapabilityProperty") shall be defined as complex attributes as specified in Table 130. The top-level attribute holds the description, the value and its unit of measure, if applicable. One sub-attribute holds the IEC 62264 ID of the property, while another one ("quantity") holds the amount of resources required and its unit of measure, if applicable.

Description	Property specification for material capabilities.	
Host Class	AutomationMLIEC62264RoleClassLib/OperationsCapabilityModel/MaterialCapability	
Attributes	id (type="xs:string")	Identification of the associated material property or equipment class property.
	quantity (type="xs:decimal")	Specifies the quantity of the material capability defined, if applicable. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

Table 130: Attribute type MaterialCapabilityProperty.

5.3.11 Process Segment Capability

RoleClass "ProcessSegmentCapability" shall be used as specified in Table 131. Instances of this role class shall be realized as internal elements in an instance hierarchy, specifying "ProcessSegmentCapability" as a supported role class or role requirement. Its purpose is the specification of the process segment that is involved in the given operations capability or process segment capability. This is realized by adding an instance of interface class "ResourceConnector" (cf. Clause 5.1) to this entity (in form of an external interface) as well as to the resource it is linked to. If a "ResourceConnector" is already existing, it can be reused.

The "description" property is to be instantiated as a "Description" header-attribute of the internal element.

The hierarchy scope of this element is defined by a relation to a "HierarchyScope" internal element. The relation is defined as follows: this element needs to define an external interface of type "HierarchyScopeConnector" that is linked via an internal link to another "HierarchyScopeConnector" external interface that is bound to a "HierarchyScope" internal element.

NOTE: Process segment capabilities should be used carefully because of possible double counts of resources [IEC 62264-2].

Class Name	ProcessSegmentCapability	
Description	Role class used for process segment capability classes.	
Parent Class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	
Path for Element Reference	AutomationMLIEC62264RoleClassLib/ProcessSegmentCapability	
Attributes (optional)	id (type="xs:string")	Defines a unique instance of a process segment capability for a specified element of the equipment hierarchy model (enterprise, site, area, work center, or work unit).
	capacityType (type="xs:string")	The capacity type. One of (nominal scaled constraint) "Available", "Unattainable", or "Committed".
	reason (type="xs:string")	Gives the reason for the capacity type.
	startTime (type="xs:dateTime")	The starting time of the time span defining the capacity type.
	endTime (type="xs:dateTime")	The ending time of the time span defining the capacity type.

Table 131: Role class ProcessSegmentCapability.

6 Referencing B2MML Files

Regarding referencing B2MML files, the following provisions apply:

- An AML object that references a B2MML document shall hold a child internal element (resembling the document) that references role class "B2mmlData" as defined in Clause 5.2.

- A reference from this "document object" to a B2MML file shall be modelled by means of a CAEX external interface of interface class "ExternalDataReference" as described in Clause 4.1.1.

- The B2MML file shall be referenced by its URI within the attribute "refURI" of this external interface. If no fragment part is defined in the URI, then the root element is implicitly referenced.

- The B2MML file shall be referenced with a specific MIME type defined in the "MIMEtype" attribute of this external interface. The MIME type shall be "application/x.b2mml+xml", in conformance with [RFC 6838].

- Referencing elements within a B2MML file shall be modeled by applying the global ID of the respective element to the fragment part of the URI, separated by a hash (#). It is to be noted that B2MML does not support the common XML notation of an "id" attribute, but instead uses an "ID" element of type "normalizedString" as a child of the element to be referenced.

- Referencing multiple B2MML files from a single AML object is allowed and shall be modeled by using multiple "document objects" as child internal elements.

- If a B2MML document is to be referenced from a role class entity, then a singleton instance of this role class shall be instantiated as an internal element, that in turn holds a "document object", as described before. The unit of measure of the associated quantity, is to be specified as the "Unit" attribute, if applicable.

7 Relation to OPC Unified Architecture

OPC Unified Architecture (UA) is an industry standard brought forward by the OPC Foundation; it defines a modern, object- and service-oriented communication stack and modeling paradigm for industrial automation [IEC 62541-1]. Its versatility allows the mapping of various domain-specific models into OPC UA equivalent information models, such as AutomationML and IEC 62264 models.

The definitions in this recommendation are (through OPC UA) closely related to two other specifications: (i) the alignment of IEC 62264 with OPC UA [OPC-IEC62264] and (ii) the alignment of AutomationML with OPC UA [DIN 16592-12]. The relations are visualized in Figure 21 and resemble transformation rules for the conversion of information from one metamodel into information of another metamodel: (i) function f describes how to transform AutomationML models into the OPC UA space, (ii) function h describes the transformation from IEC 62264 to OPC UA, and (iii) function g provides a transformation from IEC 62264 to AutomationML. It would be benefitial for a number of stakeholders if the provision f∘g = h would hold, i.e., IEC 62264 models that are mapped directly into the OPC UA space via function h have an identical representation there as if they would be first be transformed into AutomationML (via g) and only then be mapped into the OPC UA space (via f).
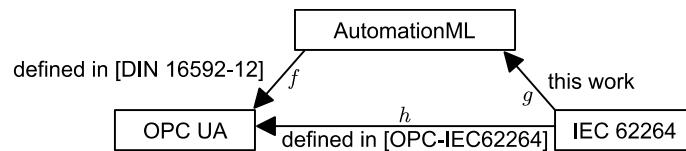
Figure 21:   Composition of transformation/alignment functions: f∘g ≠ h.

The two already defined transformation specifications ("IEC 62264 to OPC UA" [OPC-IEC62264] and "AutomationML to OPC UA" [DIN 16592-12]) each define a basic OPC UA information model that provides the base structures for domain specific information models (depicted in Figure 22 and Figure 23). Therefore, an internal element that implements the role class "PhysicalAsset", as defined in this specification, would be instantiated as an OPC UA object with a type definition pointing to a subtype of the OPC UA object type "CAEXObjectType". A physical asset instance of IEC 62264 would be instantiated as an OPC UA object with a type definition pointing to the OPC UA object type "PhysicalAssetType".
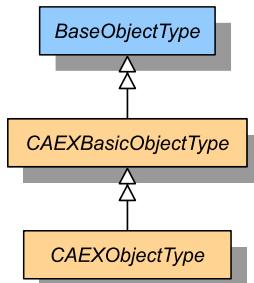
Figure 22:   Excerpt of the basic information model for AutomationML-based models (cf. [DIN 16592-12]).
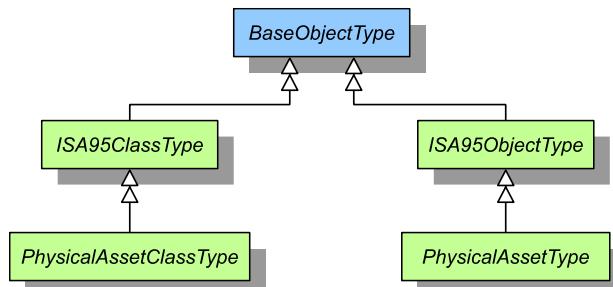
Figure 23:   Excerpt of the basic information model for IEC 62264-based models (cf. [OPC-IEC62264]).

Since an OPC UA object is allowed only one type definition, it is not possible to provide a fully compatible mapping from IEC 62264 to AutomationML. However, it is possible (and has been realized in this recommendation) to map IEC 62264 elements to AutomationML elements in a way that the corresponding

metamodel elements of OPC UA conform to each other. This has been achieved for all main concepts, except for resource test results (e.g., QualificationTestResult and EquipmentCapabilityTestResult): in [OPC-IEC62264], these entities are istances of OPC UA variable types (and thus correspond to attributes), while in this specification they are instances of type internal element and not realized as attributes. This decision has been taken in order to keep referential integrity within the AML document while relying on standard AML referencing schemes.

In a setting where both the IEC 62264 model and the AutomationML model are injected into an OPC UA server, these two model co-exist in parallel. To clarify and make explicit that two distinct OPC UA nodes describe an identical asset [DIN 16592-12] provides the reference type "HasAMLUAReference". References of this reference type point from an AutomationML node to a corresponding IEC 62264 node (cf. Figure 24). Currently, this is realized by following the external data reference, as specified in Clause 6, i.e., it is only supported in an environment where an external B2MML file is referenced.
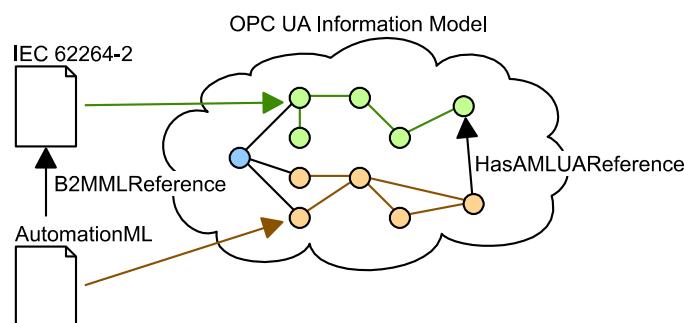
Figure 24: Referencing corresponding elelements from IEC 62264 and AutomationML in OPC UA.

In order to overcome this issue and provide a semantically similar solution to AutomationML, models that have been modeled without references to B2MML documents, the following approach is provided: internal elements and system unit classes that have been modeled with the definitions provided in this recommendation can be matched with IEC 62264 elements via their "ID" attribute. After transforming the IEC 62264 aware AutomationML model into an OPC UA information model, a second processing step could search the IEC 62264 based OPC UA space (if there is one) for elements whose ID matches that of an AutomationML based element. In that case, a reference of type "HasAMLIEC62264UAReference" shall be created, pointing from the AutomationML element to the IEC 62264 element.

Reference type "HasAMLIEC62264UAReference" is defined as a subtype of "HasAMLUAReference" and represented in the OPC UA address space as specified in Table 132.

Attributes	Value		
BrowseName	HasAMLIEC62264UAReference		
InverseName	IsAMLIEC62264ReferenceOf		
Symmetric	False		
IsAbstract	False		
References	**NodeClass**	**BrowseName**	**Comment**
Subtype of HasAMLUAReference ReferenceType, defined in [DIN 16592-12].			

Table 132: HasAMLIEC62264UAReference reference type.

The *SourceNode* of this ReferenceType is an OPC UA Node of type Object, ObjectType, or Variable which is part of a transformed AML model and that represents an element of IEC 62264.

The *TargetNode* of this ReferenceType is an OPC UA Node of any type that represents a corresponding element of IEC 62264, such as one created by applying the transformation rules defined in [OPC-IEC62264].

8 Notes regarding the Examples in the Appendices

For the sake of better comprehendability, in the code listings in Appendix E the UUIDs of AML elements have been replaced by human readable or otherwise shortened strings (e.g., the value of a corresponding "name"

attribute, if applicable). Furthermore, in all appendices some often-used CAEX path definitions are substituted by shorter strings, as depicted in Table 133.

Original	Substitution
AutomationMLInterfaceClassLib/AutomationMLBaseInterface/PPRConnector	PPRConnector
AutomationMLBaseRoleClassLib/AutomationMLBaseRole	BR
AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Process	Process
AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Product	Product
AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource	Resource
AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProcessStructure	ProcessStructure
AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ProductStructure	ProductStructure
AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure	ResourceStructure
AutomationMLExtendedRoleClassLib/Site	Site
AutomationMLExtendedRoleClassLib/Area	Area
AutomationMLExtendedRoleClassLib/ProductionLine	ProductionLine
AutomationMLExtendedRoleClassLib/WorkCell	WorkCell
AutomationMLInterfaceClassLib/AutomationMLBaseInterface/ExternalDataConnector/ExternalDataReference	EDR
AutomationMLIEC62264RoleClassLib/EquipmentModel/EquipmentClass	EquipmentClass
AutomationMLIEC62264RoleClassLib/EquipmentModel/Equipment	Equipment
AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAssetClass	PhysicalAssetClass
AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset	PhysicalAsset
AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialClass	MaterialClass
AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialDefinition	MaterialDefinition
AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ProcessSegmentDependency	ProcessSegmentDependency
AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/ProcessSegment	ProcessSegment
AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/EquipmentSegmentSpecification	EquipmentSegmentSpecification
AutomationMLIEC62264RoleClassLib/ProcessSegmentModel/MaterialSegmentSpecification	MaterialSegmentSpecification
AutomationMLIEC62264InterfaceClassLib/ResourceConnector	RC
AutomationMLIEC62264InterfaceClassLib/EquipmentAssetConnector	EAC
AutomationMLIEC62264InterfaceClassLib/DependencyConnector	DC
AutomationMLB2MMLRoleClassLib/B2mmlData	B2mmlData

Table 133: Substitutions in use in Listings 2, 5, 7, and 9.

References

[IEC 62264-1]   IEC, Enterprise-control system integration – Part 1: Models and terminology, International Electrotechnical Commission (IEC), Standard, Rev. ISO/IEC 62264-1:2013, May 2013.

[IEC 62264-2]   IEC, Enterprise-control system integration – Part 2: Objects and attributes for enterprise-control system integration, International Electrotechnical Commission (IEC), Standard, Rev. ISO/IEC 62264-2:2013, June 2013.

[IEC 62714-1]   IEC, Engineering data exchange format for use in industrial automation systems engineering – Automation markup language – Part 1: Architecture and general requirements, International Electrotechnical Commission (IEC), Standard, Rev. ISO/IEC 62714-1:2014, June 2014.

[IEC 62714-2]   IEC, Engineering data exchange format for use in industrial automation systems engineering – Automation markup language – Part 2: Role class libraries, International Electrotechnical Commission (IEC), Standard, Rev. ISO/IEC 62714-2:2015, March 2015.

[RFC 6838]   N. Freed, J. Klensin, and T. Hansen, Media Type Specifications and Registration Procedures, Internet Engineering Task Force (IETF) Best Current Practice, January 2013.

[IEC 62541-1]   IEC, OPC Unified Architecture – Part 1: Overview and Concepts, International Electrotechnical Commission (IEC), Standard, Rev. IEC 62541-1:2010, February 2010.

[DIN 16592-12]   DIN, Combining OPC Unified Architecture and Automation Markup Language, DIN Standard, DIN 16592:2016-12, December 2016.

[OPC-IEC62264]   OPC Foundation, OPC Unified Architecture for ISA-95 Common Object Model, Companion Specification, Rev. 1.00, October 2013.

Appendix A AutomationMLIEC62264InterfaceClassLib

Listing 1 depicts the complete source code of the AutomationMLIEC62264InterfaceClassLib. Conceptually, the AutomationMLIEC62264InterfaceClassLib works in conjunction with the AutomationMLIEC62264RoleClassLib.

Listing 1: AutomationML IEC 62264 interface class library.

```
1   <InterfaceClassLib ChangeMode="change" Name="AutomationMLIEC62264InterfaceClassLib">
2      <Description>IEC 62264 Interface Class Library</Description>
3      <Version ChangeMode="change">2.0.0</Version>
4      <InterfaceClass Name="HierarchyScopeConnector"
5           RefBaseClassPath=" AutomationMLInterfaceClassLib/AutomationMLBaseInterface">
6         <Description>
7            HierarchyScopeConnector shall be used in order to reference hierarchy scope
8            elements from other entities such as e.g., process segments.
9         </Description>
10     </InterfaceClass>
11     <InterfaceClass Name="ResourceConnector"
12          RefBaseClassPath=" AutomationMLInterfaceClassLib/AutomationMLBaseInterface">
13        <Description>
14           ResourceConnector shall be used in order to reference basic or complex
15           resources from complex entities such as, e.g., a person or personnel class
16           from a personnel segment requirement of a process segment.
17        </Description>
18     </InterfaceClass>
19     <InterfaceClass Name="EquipmentAssetConnector"
20          RefBaseClassPath=" AutomationMLInterfaceClassLib/AutomationMLBaseInterface">
21        <Description>
22           EquipmentAssetConnector shall be used in order to link equipment and
23           physical assets to equipment asset mappings.
24        </Description>
25     </InterfaceClass>
26     <InterfaceClass ChangeMode="change" Name="DependencyConnector"
27          RefBaseClassPath=" AutomationMLInterfaceClassLib/AutomationMLBaseInterface">
28        <Description>
29           DependencyConnector shall be used in order to link process and operations
30           segments to process and operations segment dependencies, respectively.
31        </Description>
32        <Attribute ChangeMode="create" Name="role" AttributeDataType="xs:string">
33           <Description ChangeMode="create">
34              Identifies whether the segment the interface is attached to is the source
35              ("host") or the target ("dependency") of this dependency relation.
36           </Description>
37           <Constraint ChangeMode="create" Name="AllowedValues">
38              <NominalScaledType>
39                 <RequiredValue>host</RequiredValue>
40                 <RequiredValue>dependency</RequiredValue>
41              </NominalScaledType>
42           </Constraint>
43        </Attribute>
44     </InterfaceClass>
45     <InterfaceClass Name="TestConnector"
46          RefBaseClassPath=" AutomationMLInterfaceClassLib/AutomationMLBaseInterface">
47        <Description>
48           TestConnector shall be used in order to link resources and resource types to
49           test specifications and test results.
50        </Description>
51     </InterfaceClass>
52   </InterfaceClassLib>
```

Appendix B AutomationMLIEC62264RoleClassLib

Listing 2 depicts the complete source code of the AutomationMLIEC62264RoleClassLib. Conceptually, the AutomationMLIEC62264RoleClassLib can be used without using references to external B2MML documents and thus it is independent of, but interoperable with, the AutomationMLB2MMLRoleClassLib.

Listing 2: AutomationML IEC 62264 role class library.

```
1   <RoleClassLib ChangeMode="change" Name="AutomationMLIEC62264RoleClassLib">
2       <Description>IEC 62264 Role Class Library</Description>
3       <Version ChangeMode="change">2.0.0</Version>
4       <RoleClass Name="HierarchyScope" RefBaseClassPath="BR">
5           <Attribute Name="equipmentElementLevel" AttributeDataType="xs:string">
6               <Description>
7                   Identification of the equipment level if the equipment element is
8                   defined.
9               </Description>
10          </Attribute>
11      </RoleClass>
12      <RoleClass Name="PersonnelModel" RefBaseClassPath="BR">
13          <Description>
14              Abstract role class used for structuring personnel roles.
15          </Description>
16          <RoleClass Name="PersonnelClass" RefBaseClassPath="Resource">
17              <Description>Role class used for personnel classes.</Description>
18              <Attribute Name="id" AttributeDataType="xs:string">
19                  <Description>
20                      Unique identification of a specific personnel class. These are not
21                      necessarily job titles, but identify classes that are
22                      referenced in other parts of the model.
23                  </Description>
24              </Attribute>
25          </RoleClass>
26          <RoleClass Name="Person" RefBaseClassPath="Resource">
27              <Description>Role class used for persons.</Description>
28              <Attribute Name="id" AttributeDataType="xs:string">
29                  <Description>
30                      A unique identification of a specific person, within the scope of
31                      the information exchanged (e.g. production capability,
32                      production schedule, and production performance).
33                  </Description>
34              </Attribute>
35              <Attribute Name="name" AttributeDataType="xs:string">
36                  <Description>The name of the individual.</Description>
37              </Attribute>
38          </RoleClass>
39          <RoleClass Name="QualificationTestSpecification" RefBaseClassPath="BR">
40              <Description>
41                  Role class used for qualification test specifications.
42              </Description>
43              <Attribute Name="id" AttributeDataType="xs:string">
44                  <Description>
45                      An identification of a test for certifying one or more values for
46                      one or more person properties.
47                  </Description>
48              </Attribute>
49              <Attribute Name="version" AttributeDataType="xs:string">
50                  <Description>
51                      An identification of the version of the qualification test
52                      specification.
53                  </Description>
54              </Attribute>
55          </RoleClass>
56          <RoleClass Name="QualificationTestResult" RefBaseClassPath="BR">
57              <Description>Role class used for qualification test results.</Description>
```

```
58          </RoleClass>
59      </RoleClass>
60      <RoleClass Name="EquipmentModel" RefBaseClassPath="BR">
61          <Description>
62              Abstract role class used for structuring equipment roles.
63          </Description>
64          <RoleClass Name="EquipmentClass" RefBaseClassPath="Resource">
65              <Description>Role class used for equipment classes.</Description>
66              <Attribute Name="id" AttributeDataType="xs:string">
67                  <Description>
68                      A unique identification of a specific equipment class, within the
69                      scope of the information exchanged (e.g. production
70                      capability, production schedule, production performance).
71                  </Description>
72              </Attribute>
73              <Attribute Name="equipmentLevel" AttributeDataType="xs:string">
74                  <Description>An identification of the level in the role based equipment
75                      hierarchy. One of (nominal scaled constraint): "Enterprise",
76                      "Site", "Area", "Work Center", "Process Cell", "Production Unit",
77                      "Production Line", "Storage Zone", "Work Unit", "Unit", "Work
78                      Cell", "Storage Unit".</Description>
79                  <Constraint Name="equipmentLevel">
80                      <NominalScaledType>
81                          <RequiredValue>Enterprise</RequiredValue>
82                          <RequiredValue>Site</RequiredValue>
83                          <RequiredValue>Area</RequiredValue>
84                          <RequiredValue>Work Center</RequiredValue>
85                          <RequiredValue>Process Cell</RequiredValue>
86                          <RequiredValue>Production Unit</RequiredValue>
87                          <RequiredValue>Production Line</RequiredValue>
88                          <RequiredValue>Storage Zone</RequiredValue>
89                          <RequiredValue>Work Unit</RequiredValue>
90                          <RequiredValue>Unit</RequiredValue>
91                          <RequiredValue>Work Cell</RequiredValue>
92                          <RequiredValue>Storage Unit</RequiredValue>
93                      </NominalScaledType>
94                  </Constraint>
95              </Attribute>
96          </RoleClass>
97          <RoleClass Name="Equipment" RefBaseClassPath="Resource">
98              <Description>Role class used for equipment.</Description>
99              <Attribute Name="id" AttributeDataType="xs:string">
100                 <Description>
101                     A unique identification of a specific piece of equipment, within the
102                     scope of the information exchanged (manufacturing operations
103                     definition, scheduling, capability and performance).
104                 </Description>
105             </Attribute>
106             <Attribute Name="equipmentLevel" AttributeDataType="xs:string">
107                 <Description>An identification of the level in the role based equipment
108                     hierarchy. One of (nominal scaled constraint): "Enterprise",
109                     "Site", "Area", "Work Center", "Process Cell", "Production Unit",
110                     "Production Line", "Storage Zone", "Work Unit", "Unit", "Work
111                     Cell", "Storage Unit".</Description>
112                 <Constraint Name="equipmentLevel">
113                     <NominalScaledType>
114                         <RequiredValue>Enterprise</RequiredValue>
115                         <RequiredValue>Site</RequiredValue>
116                         <RequiredValue>Area</RequiredValue>
117                         <RequiredValue>Work Center</RequiredValue>
118                         <RequiredValue>Process Cell</RequiredValue>
119                         <RequiredValue>Production Unit</RequiredValue>
120                         <RequiredValue>Production Line</RequiredValue>
121                         <RequiredValue>Storage Zone</RequiredValue>
122                         <RequiredValue>Work Unit</RequiredValue>
123                         <RequiredValue>Unit</RequiredValue>
```

```
124                <RequiredValue>Work Cell</RequiredValue>
125                <RequiredValue>Storage Unit</RequiredValue>
126            </NominalScaledType>
127        </Constraint>
128      </Attribute>
129    </RoleClass>
130    <RoleClass Name="EquipmentCapabilityTestSpecification" RefBaseClassPath="BR">
131      <Description>
132        Role class used for equipment capability test specifications.
133      </Description>
134      <Attribute Name="id" AttributeDataType="xs:string">
135        <Description>
136          An identification of a test for certifying one or more values for
137          one or more equipment properties.
138        </Description>
139      </Attribute>
140      <Attribute Name="version" AttributeDataType="xs:string">
141        <Description>
142          An identification of the version of the capability test
143          specification.
144        </Description>
145      </Attribute>
146    </RoleClass>
147    <RoleClass Name="EquipmentCapabilityTestResult" RefBaseClassPath="BR">
148      <Description>
149        Role class used for equipment capability test results.
150      </Description>
151    </RoleClass>
152  </RoleClass>
153  <RoleClass Name="PhysicalAssetModel" RefBaseClassPath="BR">
154    <Description>
155      Abstract role class for structuring physical asset roles.
156    </Description>
157    <RoleClass Name="PhysicalAssetClass" RefBaseClassPath="Resource">
158      <Description>Role class used for physical asset classes.</Description>
159      <Attribute Name="manufacturer" AttributeDataType="xs:string">
160        <Description>An identification of the manufacturer.</Description>
161      </Attribute>
162      <Attribute Name="id" AttributeDataType="xs:string">
163        <Description>The manufacturer's identification of the specific physical
164            asset class.</Description>
165      </Attribute>
166    </RoleClass>
167    <RoleClass Name="PhysicalAsset" RefBaseClassPath="Resource">
168      <Description>Role class used for physical assets.</Description>
169      <Attribute Name="id" AttributeDataType="xs:string">
170        <Description>
171          Defines a unique identification of a physical asset.
172        </Description>
173      </Attribute>
174      <Attribute Name="physicalLocation" AttributeDataType="xs:string">
175        <Description>
176          Actual physical location of the physical asset.
177        </Description>
178      </Attribute>
179      <Attribute Name="fixedAssetId" AttributeDataType="xs:string">
180        <Description>
181          Contains a unique identification for financial tracking as required
182          by laws or regulations.
183        </Description>
184      </Attribute>
185      <Attribute Name="vendorId" AttributeDataType="xs:string">
186        <Description>Contains a vendor's serial number.</Description>
187      </Attribute>
188    </RoleClass>
189    <RoleClass Name="PhysicalAssetCapabilityTestSpecification"
```

```
190                RefBaseClassPath="BR">
191          <Description>
192             Role class used for physical asset capability test specifications.
193          </Description>
194          <Attribute Name="id" AttributeDataType="xs:string">
195             <Description>
196                An identification of the specific physical asset capability test
197                specification.
198             </Description>
199          </Attribute>
200          <Attribute Name="version" AttributeDataType="xs:string">
201             <Description>
202                An identification of the version of the capability test
203                specification.
204             </Description>
205          </Attribute>
206       </RoleClass>
207       <RoleClass Name="PhysicalAssetCapabilityTestResult" RefBaseClassPath="BR">
208          <Description>
209             Role class used for physical asset capability test results.
210          </Description>
211       </RoleClass>
212       <RoleClass Name="EquipmentAssetMapping" RefBaseClassPath="BR">
213          <Description>
214             EquipmentAssetMapping shall be used to link physical assets to
215             equipment.
216          </Description>
217          <Attribute Name="id" AttributeDataType="xs:string">
218             <Description>
219                An identification of the specific equipment asset mapping.
220             </Description>
221          </Attribute>
222          <Attribute Name="startTime" AttributeDataType="xs:dateTime">
223             <Description>The starting time of the association.</Description>
224          </Attribute>
225          <Attribute Name="endTime" AttributeDataType="xs:dateTime">
226             <Description>The ending time of the association.</Description>
227          </Attribute>
228       </RoleClass>
229    </RoleClass>
230    <RoleClass Name="MaterialModel" RefBaseClassPath="BR">
231       <Description>
232          Abstract role class for structuring material roles.
233       </Description>
234       <RoleClass Name="MaterialClass" RefBaseClassPath="Product">
235          <Description>Role class used for material classes.</Description>
236          <Attribute Name="id" AttributeDataType="xs:string">
237             <Description>
238                A unique identification of a specific material class, within the
239                scope of the information exchanged (e.g. production
240                capability, production schedule, production performance)
241             </Description>
242          </Attribute>
243          <Attribute Name="assemblyType" AttributeDataType="xs:string">
244             <Description>Defines the type of the assembly. One of (nominal scaled
245                constraint) "Physical" or "Logical". Physical: the components of
246                the assembly are physically connected or in the same area.
247                Logical: the components of the assembly are not necessarily
248                physically connected or in the same area.</Description>
249          <Constraint Name="assemblyType">
250             <NominalScaledType>
251                <RequiredValue>Physical</RequiredValue>
252                <RequiredValue>Logical</RequiredValue>
253             </NominalScaledType>
254          </Constraint>
255          </Attribute>
```

```
256          <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
257             <Description>Defines the type of the relationships. One of (nominal
258                 scaled constraint) "Permanent" or "Transient". Permanent: an
259                 assembly that is not intended to be split during the production
260                 process. Transient: a temporary assembly used during production,
261                 such as a pallet of different materials or a batch
262                 kit.</Description>
263             <Constraint Name="assemblyRelationship">
264                <NominalScaledType>
265                   <RequiredValue>Permanent</RequiredValue>
266                   <RequiredValue>Transient</RequiredValue>
267                </NominalScaledType>
268             </Constraint>
269          </Attribute>
270       </RoleClass>
271       <RoleClass Name="MaterialDefinition" RefBaseClassPath="Product">
272          <Description>Role class used for material definitions.</Description>
273          <Attribute Name="id" AttributeDataType="xs:string">
274             <Description>
275                A unique identification of a specific material definition, within
276                the scope of the information exchanged (e.g. operations
277                capability, operations schedule, operations performance).
278             </Description>
279          </Attribute>
280          <Attribute Name="assemblyType" AttributeDataType="xs:string">
281             <Description>Defines the type of the assembly. One of (nominal scaled
282                 constraint) "Physical" or "Logical". Physical: the components of
283                 the assembly are physically connected or in the same area.
284                 Logical: the components of the assembly are not necessarily
285                 physically connected or in the same area.</Description>
286             <Constraint Name="assemblyType">
287                <NominalScaledType>
288                   <RequiredValue>Physical</RequiredValue>
289                   <RequiredValue>Logical</RequiredValue>
290                </NominalScaledType>
291             </Constraint>
292          </Attribute>
293          <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
294             <Description>Defines the type of the relationships. One of (nominal
295                 scaled constraint) "Permanent" or "Transient". Permanent: an
296                 assembly that is not intended to be split during the production
297                 process. Transient: a temporary assembly used during production,
298                 such as a pallet of different materials or a batch
299                 kit.</Description>
300             <Constraint Name="assemblyRelationship">
301                <NominalScaledType>
302                   <RequiredValue>Permanent</RequiredValue>
303                   <RequiredValue>Transient</RequiredValue>
304                </NominalScaledType>
305             </Constraint>
306          </Attribute>
307       </RoleClass>
308       <RoleClass Name="MaterialLot" RefBaseClassPath="Product">
309          <Description>Role class used for material lots.</Description>
310          <Attribute Name="id" AttributeDataType="xs:string">
311             <Description>
312                A unique identification of a specific material lot, within the scope
313                of the information exchanged (e.g. operations capability,
314                operations schedule, operations performance).
315             </Description>
316          </Attribute>
317          <Attribute Name="assemblyType" AttributeDataType="xs:string">
318             <Description>Defines the type of the assembly. One of (nominal scaled
319                 constraint) "Physical" or "Logical". Physical: the components of
320                 the assembly are physically connected or in the same area.
321                 Logical: the components of the assembly are not necessarily
```

```
322                physically connected or in the same area.</Description>
323            <Constraint Name="assemblyType">
324               <NominalScaledType>
325                  <RequiredValue>Physical</RequiredValue>
326                  <RequiredValue>Logical</RequiredValue>
327               </NominalScaledType>
328            </Constraint>
329         </Attribute>
330         <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
331            <Description>Defines the type of the relationships. One of (nominal
332                scaled constraint) "Permanent" or "Transient". Permanent: an
333                assembly that is not intended to be split during the production
334                process. Transient: a temporary assembly used during production,
335                such as a pallet of different materials or a batch
336                kit.</Description>
337            <Constraint Name="assemblyRelationship">
338               <NominalScaledType>
339                  <RequiredValue>Permanent</RequiredValue>
340                  <RequiredValue>Transient</RequiredValue>
341               </NominalScaledType>
342            </Constraint>
343         </Attribute>
344         <Attribute Name="status" AttributeDataType="xs:string">
345            <Description>Status of the material lot, e.g. "released", "approved",
346                "blocked", "in process", "in quality check".</Description>
347         </Attribute>
348         <Attribute Name="storageLocation" AttributeDataType="xs:string">
349            <Description>
350               An identification of the storage location or a physical location of
351               the material lot.
352            </Description>
353         </Attribute>
354         <Attribute Name="quantity" AttributeDataType="xs:string">
355            <Description>The quantity of the material lot.</Description>
356         </Attribute>
357      </RoleClass>
358      <RoleClass Name="MaterialSublot" RefBaseClassPath="Product">
359         <Description>Role class used for material sublots.</Description>
360         <Attribute Name="id" AttributeDataType="xs:string">
361            <Description>
362               A unique identification of a specific material sublot, within the
363               scope of the information exchanged (e.g. production
364               capability, production schedule, production performance).
365            </Description>
366         </Attribute>
367         <Attribute Name="assemblyType" AttributeDataType="xs:string">
368            <Description>Defines the type of the assembly. One of (nominal scaled
369                constraint) "Physical" or "Logical". Physical: the components of
370                the assembly are physically connected or in the same area.
371                Logical: the components of the assembly are not necessarily
372                physically connected or in the same area.</Description>
373            <Constraint Name="assemblyType">
374               <NominalScaledType>
375                  <RequiredValue>Physical</RequiredValue>
376                  <RequiredValue>Logical</RequiredValue>
377               </NominalScaledType>
378            </Constraint>
379         </Attribute>
380         <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
381            <Description>Defines the type of the relationships. One of (nominal
382                scaled constraint) "Permanent" or "Transient". Permanent: an
383                assembly that is not intended to be split during the production
384                process. Transient: a temporary assembly used during production,
385                such as a pallet of different materials or a batch
386                kit.</Description>
387            <Constraint Name="assemblyRelationship">
```

```
388                    <NominalScaledType>
389                        <RequiredValue>Permanent</RequiredValue>
390                        <RequiredValue>Transient</RequiredValue>
391                    </NominalScaledType>
392                </Constraint>
393            </Attribute>
394            <Attribute Name="status" AttributeDataType="xs:string">
395                <Description>Status of the material sublot, e.g. "released",
396                    "approved", "blocked", "in process", "in quality
397                    check".</Description>
398            </Attribute>
399            <Attribute Name="storageLocation" AttributeDataType="xs:string">
400                <Description>
401                    An identification of the storage location or a physical location of
402                    the material sublot.
403                </Description>
404            </Attribute>
405            <Attribute Name="quantity" AttributeDataType="xs:string">
406                <Description>The quantity of the material sublot.</Description>
407            </Attribute>
408        </RoleClass>
409        <RoleClass Name="MaterialTestSpecification" RefBaseClassPath="BR">
410            <Description>
411                Role class used for material test specifications.
412            </Description>
413            <Attribute Name="id" AttributeDataType="xs:string">
414                <Description>
415                    An identification of a test for certifying one or more values for
416                    one or more material properties.
417                </Description>
418            </Attribute>
419            <Attribute Name="version" AttributeDataType="xs:string">
420                <Description>
421                    An identification of the version of the maerial test specification.
422                </Description>
423            </Attribute>
424        </RoleClass>
425        <RoleClass Name="MaterialTestResult" RefBaseClassPath="BR">
426            <Description>Role class used for material test results.</Description>
427        </RoleClass>
428        <RoleClass Name="MaterialAssembly" RefBaseClassPath="BR">
429            <Description>
430                Role class used for specifying material assemblies.
431            </Description>
432        </RoleClass>
433    </RoleClass>
434    <RoleClass Name="ProcessSegmentModel" RefBaseClassPath="BR">
435        <Description>
436            Abstract role class for structuring process segment roles.
437        </Description>
438        <RoleClass Name="ProcessSegment" RefBaseClassPath="Process">
439            <Description>Role class used for process segments.</Description>
440            <Attribute Name="id" AttributeDataType="xs:string">
441                <Description>
442                    A unique identification of a process segment, within the scope of
443                    the information exchanged (e.g. operations capability,
444                    operations schedule, operations performance).
445                </Description>
446            </Attribute>
447            <Attribute Name="operationsType" AttributeDataType="xs:string">
448                <Description>Describes the category of the activity. One of (nominal
449                    scaled constraint) "Production", "Maintenance", "Quality",
450                    "Inventory", or "Mixed". "Mixed" shall be used when the activity
451                    contains several categories of process segments.</Description>
452                <Constraint Name="operationsType">
453                    <NominalScaledType>
```

```
454                    <RequiredValue>Production</RequiredValue>
455                    <RequiredValue>Maintenance</RequiredValue>
456                    <RequiredValue>Quality</RequiredValue>
457                    <RequiredValue>Inventory</RequiredValue>
458                    <RequiredValue>Mixed</RequiredValue>
459                 </NominalScaledType>
460              </Constraint>
461           </Attribute>
462           <Attribute Name="duration" AttributeDataType="xs:decimal">
463              <Description>Duration of process segment, if known.</Description>
464           </Attribute>
465        </RoleClass>
466        <RoleClass Name="PersonnelSegmentSpecification" RefBaseClassPath="BR">
467           <Description>
468              Role class used for personnel segment specifications.
469           </Description>
470           <Attribute Name="personnelUse" AttributeDataType="xs:string">
471              <Description>Defines the expected use of the personnel class or person,
472                    e.g. "Allocated" or "Certified".</Description>
473           </Attribute>
474           <Attribute Name="quantity" AttributeDataType="xs:decimal">
475              <Description>
476                 Specifies the personnel resource required for the parent process
477                 segment, if applicable.
478              </Description>
479           </Attribute>
480        </RoleClass>
481        <RoleClass Name="EquipmentSegmentSpecification" RefBaseClassPath="BR">
482           <Description>
483              Role class used for equipment segment specifications.
484           </Description>
485           <Attribute Name="equipmentUse" AttributeDataType="xs:string">
486              <Description>Defines the expected use of the equipment class or
487                    equipment in the context of the process segment, e.g. "Part
488                    Milling", "Remove Motor", "Run Test", and "Material
489                    Movement".</Description>
490           </Attribute>
491           <Attribute Name="quantity" AttributeDataType="xs:decimal">
492              <Description>
493                 Specifies the amount of resources required, if applicable.
494              </Description>
495           </Attribute>
496        </RoleClass>
497        <RoleClass Name="PhysicalAssetSegmentSpecification" RefBaseClassPath="BR">
498           <Description>
499              Role class used for physical asset segment specifications.
500           </Description>
501           <Attribute Name="physicalAssetUse" AttributeDataType="xs:string">
502              <Description>
503                 Defines the expected use of the physical asset class or physical
504                 asset in the context of the process segment.
505              </Description>
506           </Attribute>
507           <Attribute Name="quantity" AttributeDataType="xs:decimal">
508              <Description>
509                 Specifies the amount of resources required, if applicable.
510              </Description>
511           </Attribute>
512        </RoleClass>
513        <RoleClass Name="MaterialSegmentSpecification" RefBaseClassPath="BR">
514           <Description>
515              Role class used for material segment specifications.
516           </Description>
517           <Attribute Name="assemblyType" AttributeDataType="xs:string">
518              <Description>Defines the type of the assembly. One of (nominal scaled
519                    constraint) "Physical" or "Logical". Physical: the components of
```

```
520                    the assembly are physically connected or in the same area.
521                    Logical: the components of the assembly are not necessarily
522                    physically connected or in the same area.</Description>
523            <Constraint Name="assemblyType">
524                <NominalScaledType>
525                    <RequiredValue>Physical</RequiredValue>
526                    <RequiredValue>Logical</RequiredValue>
527                </NominalScaledType>
528            </Constraint>
529         </Attribute>
530         <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
531            <Description>Defines the type of the relationships. One of (nominal
532                    scaled constraint) "Permanent" or "Transient". Permanent: an
533                    assembly that is not intended to be split during the production
534                    process. Transient: a temporary assembly used during production,
535                    such as a pallet of different materials or a batch
536                    kit.</Description>
537            <Constraint Name="assemblyRelationship">
538                <NominalScaledType>
539                    <RequiredValue>Permanent</RequiredValue>
540                    <RequiredValue>Transient</RequiredValue>
541                </NominalScaledType>
542            </Constraint>
543         </Attribute>
544         <Attribute Name="materialUse" AttributeDataType="xs:string">
545            <Description>Defines the material use. One of (nominal scaled
546                    constraint): "Consumable", "Material Consumed", and "Material
547                    Produced".</Description>
548            <Constraint Name="materialUse">
549                <NominalScaledType>
550                    <RequiredValue>Consumable</RequiredValue>
551                    <RequiredValue>Material Consumed</RequiredValue>
552                    <RequiredValue>Material Produced</RequiredValue>
553                </NominalScaledType>
554            </Constraint>
555         </Attribute>
556         <Attribute Name="quantity" AttributeDataType="xs:decimal">
557            <Description>Specifies the amount of resources required.</Description>
558         </Attribute>
559      </RoleClass>
560      <RoleClass Name="ProcessSegmentDependency" RefBaseClassPath="BR">
561         <Description>
562            Role class used for process segment dependencies.
563         </Description>
564         <Attribute Name="id" AttributeDataType="xs:string">
565            <Description>
566                The identification of the unique instance of the process segment
567                dependency.
568            </Description>
569         </Attribute>
570         <Attribute Name="dependencyType" AttributeDataType="xs:string">
571            <Description>
572                Defines the execution dependency constraints of one segment by
573                another segment.
574            </Description>
575         </Attribute>
576         <Attribute Name="dependencyFactor" AttributeDataType="xs:decimal">
577            <Description>Factor used by dependency.</Description>
578         </Attribute>
579      </RoleClass>
580   </RoleClass>
581   <RoleClass Name="OperationsDefinitionModel" RefBaseClassPath="BR">
582      <Description>
583         Abstract role class used for structuring operations definition roles.
584      </Description>
585      <RoleClass Name="OperationsDefinition" RefBaseClassPath="ProcessStructure">
```

```
586          <Description>Role class used for operations definitions.</Description>
587          <Attribute Name="id" AttributeDataType="xs:string">
588             <Description>
589                Uniquely identifies the operations definition.
590             </Description>
591          </Attribute>
592          <Attribute Name="version" AttributeDataType="xs:string">
593             <Description>
594                An identification of the version of the operations definition.
595             </Description>
596          </Attribute>
597          <Attribute Name="operationsType" AttributeDataType="xs:string">
598             <Description>Describes the category of operation. One of (nominal
599                scaled constraint) "Production", "Maintenance", "Quality",
600                "Inventory", or "Mixed". "Mixed" shall be used when the
601                operations definition contains several types of operations
602                requests and/or segment requirements.</Description>
603          <Constraint Name="operationsType">
604             <NominalScaledType>
605                <RequiredValue>Production</RequiredValue>
606                <RequiredValue>Maintenance</RequiredValue>
607                <RequiredValue>Quality</RequiredValue>
608                <RequiredValue>Inventory</RequiredValue>
609                <RequiredValue>Mixed</RequiredValue>
610             </NominalScaledType>
611          </Constraint>
612          </Attribute>
613          <Attribute Name="workDefinitionId" AttributeDataType="xs:string">
614             <Description>
615                Identification of the external work definition associated with this
616                operations definition.
617             </Description>
618          </Attribute>
619          <Attribute Name="billOfResourceId" AttributeDataType="xs:string">
620             <Description>
621                Identification of the external bill of resources associated with
622                this operations definition.
623             </Description>
624          </Attribute>
625       </RoleClass>
626       <RoleClass Name="OperationsMaterialBill" RefBaseClassPath="BR">
627          <Description>Role class used for operations material bills.</Description>
628          <Attribute Name="id" AttributeDataType="xs:string">
629             <Description>
630                Unique identification of a manufacturing bill.
631             </Description>
632          </Attribute>
633       </RoleClass>
634       <RoleClass Name="OperationsMaterialBillItem" RefBaseClassPath="BR">
635          <Description>
636             Role class used for operations material bill items.
637          </Description>
638          <Attribute Name="id" AttributeDataType="xs:string">
639             <Description>Unique identification of a bill item.</Description>
640          </Attribute>
641          <Attribute Name="useType" AttributeDataType="xs:string">
642             <Description>Defines the use of the material. One of (nominal scaled
643                constraint): "Consumed" or "Produced". Consumed: Indicates that
644                bill items are all consumed materials. Produced: Indicates that
645                bill items are all produced materials.</Description>
646          <Constraint Name="useType">
647             <NominalScaledType>
648                <RequiredValue>Consumed</RequiredValue>
649                <RequiredValue>Produced</RequiredValue>
650             </NominalScaledType>
651          </Constraint>
```

```
652            </Attribute>
653            <Attribute Name="assemblyType" AttributeDataType="xs:string">
654               <Description>Defines the type of the assembly. One of (nominal scaled
655                   constraint) "Physical" or "Logical". Physical: the components of
656                   the assembly are physically connected or in the same area.
657                   Logical: the components of the assembly are not necessarily
658                   physically connected or in the same area.</Description>
659               <Constraint Name="assemblyType">
660                  <NominalScaledType>
661                     <RequiredValue>Physical</RequiredValue>
662                     <RequiredValue>Logical</RequiredValue>
663                  </NominalScaledType>
664               </Constraint>
665            </Attribute>
666            <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
667               <Description>Defines the type of the relationships. One of (nominal
668                   scaled constraint) "Permanent" or "Transient". Permanent: an
669                   assembly that is not intended to be split during the production
670                   process. Transient: a temporary assembly used during production,
671                   such as a pallet of different materials or a batch
672                   kit.</Description>
673               <Constraint Name="assemblyRelationship">
674                  <NominalScaledType>
675                     <RequiredValue>Permanent</RequiredValue>
676                     <RequiredValue>Transient</RequiredValue>
677                  </NominalScaledType>
678               </Constraint>
679            </Attribute>
680            <Attribute Name="quantity" AttributeDataType="xs:decimal">
681               <Description>Specifies the amount of resources required.</Description>
682            </Attribute>
683         </RoleClass>
684         <RoleClass Name="OperationsSegment" RefBaseClassPath="Process">
685            <Description>Role class used for operations segments.</Description>
686            <Attribute Name="id" AttributeDataType="xs:string">
687               <Description>Unique identification of a specific segment.</Description>
688            </Attribute>
689            <Attribute Name="descriptions" AttributeDataType="xs:string">
690               <Description>
691                  Contains additional information about the segment.
692               </Description>
693            </Attribute>
694            <Attribute Name="duration" AttributeDataType="xs:string">
695               <Description>Duration of segment, if known.</Description>
696            </Attribute>
697            <Attribute Name="operationsType" AttributeDataType="xs:string">
698               <Description>Describes the category of operation. One of (nominal
699                   scaled constraint) "Production", "Maintenance", "Quality",
700                   "Inventory", or "Mixed". "Mixed" shall be used when the
701                   operations segment contains several types of operations requests
702                   and/or segment requirements.</Description>
703               <Constraint Name="operationsType">
704                  <NominalScaledType>
705                     <RequiredValue>Production</RequiredValue>
706                     <RequiredValue>Maintenance</RequiredValue>
707                     <RequiredValue>Quality</RequiredValue>
708                     <RequiredValue>Inventory</RequiredValue>
709                     <RequiredValue>Mixed</RequiredValue>
710                  </NominalScaledType>
711               </Constraint>
712            </Attribute>
713            <Attribute Name="workDefinitionId" AttributeDataType="xs:string">
714               <Description>
715                  Identification of the external work definition associated with this
716                  operations segment.
717               </Description>
```

```
718              </Attribute>
719          </RoleClass>
720          <RoleClass Name="PersonnelSpecification" RefBaseClassPath="BR">
721              <Description>Role class used for personnel specifications.</Description>
722              <Attribute Name="personnelUse" AttributeDataType="xs:string">
723                  <Description>
724                      Defines the expected use of the personnel class or person.
725                  </Description>
726              </Attribute>
727              <Attribute Name="quantity" AttributeDataType="xs:decimal">
728                  <Description>
729                      Specifies the amount of personnel resources required for the parent
730                      segment, if applicable.
731                  </Description>
732              </Attribute>
733          </RoleClass>
734          <RoleClass Name="EquipmentSpecification" RefBaseClassPath="BR">
735              <Description>Role class used for equipment specifications.</Description>
736              <Attribute Name="equipmentUse" AttributeDataType="xs:string">
737                  <Description>
738                      Defines the expected use of the equipment class or equipment.
739                  </Description>
740              </Attribute>
741              <Attribute Name="quantity" AttributeDataType="xs:decimal">
742                  <Description>
743                      Specifies the amount of equipment resources required for the parent
744                      segment, if applicable.
745                  </Description>
746              </Attribute>
747          </RoleClass>
748          <RoleClass Name="PhysicalAssetSpecification" RefBaseClassPath="BR">
749              <Description>
750                  Role class used for physical asset specifications.
751              </Description>
752              <Attribute Name="physicalAssetUse" AttributeDataType="xs:string">
753                  <Description>
754                      Defines the expected use of the physical asset class or physical
755                      asset.
756                  </Description>
757              </Attribute>
758              <Attribute Name="quantity" AttributeDataType="xs:decimal">
759                  <Description>
760                      Specifies the amount of physical asset resources required for the
761                      parent segment, if applicable.
762                  </Description>
763              </Attribute>
764          </RoleClass>
765          <RoleClass Name="MaterialSpecification" RefBaseClassPath="BR">
766              <Description>Role class used for material specifications.</Description>
767              <Attribute Name="materialUse" AttributeDataType="xs:string">
768                  <Description>Defines the expected material use. One of (nominal scaled
769                      constraint) "Material Consumed", "Material Produced", or
770                      "Consumable".</Description>
771                  <Constraint Name="materialUse">
772                      <NominalScaledType>
773                          <RequiredValue>Material Consumed</RequiredValue>
774                          <RequiredValue>Material Produced</RequiredValue>
775                          <RequiredValue>Consumable</RequiredValue>
776                      </NominalScaledType>
777                  </Constraint>
778              </Attribute>
779              <Attribute Name="quantity" AttributeDataType="xs:decimal">
780                  <Description>
781                      Specifies the amount of material resources required for the parent
782                      segment, if applicable.
783                  </Description>
```

```
784              </Attribute>
785              <Attribute Name="assemblyType" AttributeDataType="xs:string">
786                  <Description>Defines the type of the assembly. One of (nominal scaled
787                      constraint) "Physical" or "Logical". Physical: the components of
788                      the assembly are physically connected or in the same area.
789                      Logical: the components of the assembly are not necessarily
790                      physically connected or in the same area.</Description>
791                  <Constraint Name="assemblyType">
792                      <NominalScaledType>
793                          <RequiredValue>Physical</RequiredValue>
794                          <RequiredValue>Logical</RequiredValue>
795                      </NominalScaledType>
796                  </Constraint>
797              </Attribute>
798              <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
799                  <Description>Defines the type of the relationships. One of (nominal
800                      scaled constraint) "Permanent" or "Transient". Permanent: an
801                      assembly that is not intended to be split during the production
802                      process. Transient: a temporary assembly used during production,
803                      such as a pallet of different materials or a batch
804                      kit.</Description>
805                  <Constraint Name="assemblyRelationship">
806                      <NominalScaledType>
807                          <RequiredValue>Permanent</RequiredValue>
808                          <RequiredValue>Transient</RequiredValue>
809                      </NominalScaledType>
810                  </Constraint>
811              </Attribute>
812          </RoleClass>
813          <RoleClass Name="OperationsSegmentDependency" RefBaseClassPath="BR">
814              <Description>
815                  Role class used for operations segment dependencies.
816              </Description>
817              <Attribute Name="id" AttributeDataType="xs:string">
818                  <Description>
819                      Identification of the unique instance of the operations segment
820                      dependency.
821                  </Description>
822              </Attribute>
823              <Attribute Name="dependencyType" AttributeDataType="xs:string">
824                  <Description>
825                      Defines the execution dependency constraints of one segment by
826                      another segment.
827                  </Description>
828              </Attribute>
829              <Attribute Name="dependencyFactor" AttributeDataType="xs:string">
830                  <Description>Factor used by dependency.</Description>
831              </Attribute>
832          </RoleClass>
833      </RoleClass>
834      <RoleClass Name="OperationsScheduleModel" RefBaseClassPath="BR">
835          <Description>
836              Abstract role class used for structuring operations schedule roles.
837          </Description>
838          <RoleClass Name="OperationsSchedule" RefBaseClassPath="ProcessStructure">
839              <Description>Role class used for operations schedules.</Description>
840              <Attribute Name="id" AttributeDataType="xs:string">
841                  <Description>
842                      Uniquely identifies the operations schedule and could include
843                      version and revision identification.
844                  </Description>
845              </Attribute>
846              <Attribute Name="operationsType" AttributeDataType="xs:string">
847                  <Description>Describes the category of operation. One of (nominal
848                      scaled constraint) "Production", "Maintenance", "Quality",
849                      "Inventory", or "Mixed". "Mixed" shall be used when the
```

```
850                    operations definition contains several types of operations
851                    requests and/or segment requirements.</Description>
852            <Constraint Name="operationsType">
853                <NominalScaledType>
854                    <RequiredValue>Production</RequiredValue>
855                    <RequiredValue>Maintenance</RequiredValue>
856                    <RequiredValue>Quality</RequiredValue>
857                    <RequiredValue>Inventory</RequiredValue>
858                    <RequiredValue>Mixed</RequiredValue>
859                </NominalScaledType>
860            </Constraint>
861        </Attribute>
862        <Attribute Name="startTime" AttributeDataType="xs:dateTime">
863            <Description>
864                The starting time for the associated operations schedule, if
865                applicable.
866            </Description>
867        </Attribute>
868        <Attribute Name="endTime" AttributeDataType="xs:dateTime">
869            <Description>
870                The ending time for the associated operations schedule, if
871                applicable.
872            </Description>
873        </Attribute>
874        <Attribute Name="publishedDate" AttributeDataType="xs:dateTime">
875            <Description>
876                The date and time on which the operations schedule was published or
877                generated.
878            </Description>
879        </Attribute>
880        <Attribute Name="scheduledState" AttributeDataType="xs:string">
881            <Description>Indicates the state of the operations schedule. One of
882                (nominal scaled constraint) "Forecast" or "Released". Forecast:
883                the requirements have not been released for use. Released: the
884                requirements have been released for use.</Description>
885            <Constraint Name="scheduledState">
886                <NominalScaledType>
887                    <RequiredValue>Forecast</RequiredValue>
888                    <RequiredValue>Released</RequiredValue>
889                </NominalScaledType>
890            </Constraint>
891        </Attribute>
892    </RoleClass>
893    <RoleClass Name="OperationsRequest" RefBaseClassPath="ProcessStructure">
894        <Description>Role class used for operations requests.</Description>
895        <Attribute Name="id" AttributeDataType="xs:string">
896            <Description>
897                Unique identification of the operations request.
898            </Description>
899        </Attribute>
900        <Attribute Name="operationsType" AttributeDataType="xs:string">
901            <Description>Describes the category of operations. One of (nominal
902                scaled constraint) "Production", "Maintenance", "Quality",
903                "Inventory", or "Mixed". "Mixed" shall be used when the
904                operations definition contains several types of operations
905                requests and/or segment requirements.</Description>
906            <Constraint Name="operationsType">
907                <NominalScaledType>
908                    <RequiredValue>Production</RequiredValue>
909                    <RequiredValue>Maintenance</RequiredValue>
910                    <RequiredValue>Quality</RequiredValue>
911                    <RequiredValue>Inventory</RequiredValue>
912                    <RequiredValue>Mixed</RequiredValue>
913                </NominalScaledType>
914            </Constraint>
915        </Attribute>
```

```
916            <Attribute Name="startTime" AttributeDataType="xs:dateTime">
917                <Description>
918                    When operation is to be started operations schedule, if applicable.
919                </Description>
920            </Attribute>
921            <Attribute Name="endTime" AttributeDataType="xs:dateTime">
922                <Description>
923                    When operation is to be completed, if applicable.
924                </Description>
925            </Attribute>
926            <Attribute Name="priority" AttributeDataType="xs:string">
927                <Description>The priority of the request, if applicable.</Description>
928            </Attribute>
929            <Attribute Name="scheduledState" AttributeDataType="xs:string">
930                <Description>Indicates the state of the operations request. One of
931                    (nominal scaled constraint) "Forecast" or "Released". Forecast:
932                    the requirements have not been released for use. Released: the
933                    requirements have been released for use.</Description>
934                <Constraint Name="scheduledState">
935                    <NominalScaledType>
936                        <RequiredValue>Forecast</RequiredValue>
937                        <RequiredValue>Released</RequiredValue>
938                    </NominalScaledType>
939                </Constraint>
940            </Attribute>
941        </RoleClass>
942        <RoleClass Name="SegmentRequirement" RefBaseClassPath="Process">
943            <Description>Role class used for segment requirements.</Description>
944            <Attribute Name="id" AttributeDataType="xs:string">
945                <Description>
946                    Unique identification of the segment requirement.
947                </Description>
948            </Attribute>
949            <Attribute Name="operationsType" AttributeDataType="xs:string">
950                <Description>Describes the category of operation. One of (nominal
951                    scaled constraint) "Production", "Maintenance", "Quality",
952                    "Inventory", or "Mixed". "Mixed" shall be used when the
953                    operations definition contains several types of operations
954                    requests and/or segment requirements.</Description>
955                <Constraint Name="operationsType">
956                    <NominalScaledType>
957                        <RequiredValue>Production</RequiredValue>
958                        <RequiredValue>Maintenance</RequiredValue>
959                        <RequiredValue>Quality</RequiredValue>
960                        <RequiredValue>Inventory</RequiredValue>
961                        <RequiredValue>Mixed</RequiredValue>
962                    </NominalScaledType>
963                </Constraint>
964            </Attribute>
965            <Attribute Name="earliestStartTime" AttributeDataType="xs:dateTime">
966                <Description>
967                    The expected earliest start time of this segment requirement, if
968                    applicable.
969                </Description>
970            </Attribute>
971            <Attribute Name="latestEndTime" AttributeDataType="xs:dateTime">
972                <Description>
973                    The expected latest ending time of this segment requirement, if
974                    applicable.
975                </Description>
976            </Attribute>
977            <Attribute Name="duration" AttributeDataType="xs:decimal">
978                <Description>
979                    The expected duration of this segment requirement, if applicable.
980                    Note: this should match the associated segment duration.
981                </Description>
```

```
982              </Attribute>
983              <Attribute Name="segmentState" AttributeDataType="xs:string">
984                  <Description>Indicates the state of the segment request. One of
985                      (nominal scaled constraint) "Forecast" or "Released". Forecast:
986                      the requirements have not been released for use. Released: the
987                      requirements have been released for use.</Description>
988                  <Constraint Name="segmentState">
989                      <NominalScaledType>
990                          <RequiredValue>Forecast</RequiredValue>
991                          <RequiredValue>Released</RequiredValue>
992                      </NominalScaledType>
993                  </Constraint>
994              </Attribute>
995          </RoleClass>
996          <RoleClass Name="PersonnelRequirement" RefBaseClassPath="BR">
997              <Description>Role class used for personnel requirements.</Description>
998              <Attribute Name="personnelUse" AttributeDataType="xs:string">
999                  <Description>
1000                         Defines the expected use of the personnel class or person.
1001                     </Description>
1002             </Attribute>
1003             <Attribute Name="quantity" AttributeDataType="xs:decimal">
1004                 <Description>
1005                        Specifies the amount of personnel resources required for the parent
1006                        segment, if applicable. Applies to each member of the person
1007                        and personnel class sets.
1008                    </Description>
1009             </Attribute>
1010         </RoleClass>
1011         <RoleClass Name="EquipmentRequirement" RefBaseClassPath="BR">
1012             <Description>Role class used for equipment requirements.</Description>
1013             <Attribute Name="equipmentUse" AttributeDataType="xs:string">
1014                 <Description>
1015                        Defines the expected use of the equipment class or equipment.
1016                    </Description>
1017             </Attribute>
1018             <Attribute Name="quantity" AttributeDataType="xs:decimal">
1019                 <Description>
1020                        Specifies the amount of equipment resources required for the parent
1021                        segment, if applicable. Applies to each member of the
1022                        equipment and equipment class sets.
1023                    </Description>
1024             </Attribute>
1025             <Attribute Name="equipmentLevel" AttributeDataType="xs:string">
1026                 <Description>
1027                        A definition of the level of the associated element of the equipment
1028                        model.
1029                    </Description>
1030             </Attribute>
1031         </RoleClass>
1032         <RoleClass Name="PhysicalAssetRequirement" RefBaseClassPath="BR">
1033             <Description>
1034                    Role class used for physical asset requirements.
1035                </Description>
1036             <Attribute Name="physicalAssetUse" AttributeDataType="xs:string">
1037                 <Description>
1038                        Defines the expected use of the physical asset class or physical
1039                        asset.
1040                    </Description>
1041             </Attribute>
1042             <Attribute Name="quantity" AttributeDataType="xs:decimal">
1043                 <Description>
1044                        Specifies the amount of physical asset resources required for the
1045                        parent segment, if applicable. Applies to each member of the
1046                        physical asset and physical asset class sets.
1047                    </Description>
```

```
1048            </Attribute>
1049            <Attribute Name="equipmentLevel" AttributeDataType="xs:string">
1050                <Description>
1051                    A level definition for the associated element in the hierarchy of
1052                    the physical asset model.
1053                </Description>
1054            </Attribute>
1055        </RoleClass>
1056        <RoleClass Name="MaterialRequirement" RefBaseClassPath="BR">
1057            <Description>Role class used for material requirements.</Description>
1058            <Attribute Name="materialUse" AttributeDataType="xs:string">
1059                <Description>Identifies the use of the material.</Description>
1060            </Attribute>
1061            <Attribute Name="storageLocation" AttributeDataType="xs:string">
1062                <Description>
1063                    Identifies the proposed location of the material, if applicable.
1064                </Description>
1065            </Attribute>
1066            <Attribute Name="quantity" AttributeDataType="xs:decimal">
1067                <Description>
1068                    Specifies the amount of material to be used, if applicable. Applies
1069                    to each member of the material lot, material definition, or
1070                    material class sets.
1071                </Description>
1072            </Attribute>
1073            <Attribute Name="assemblyType" AttributeDataType="xs:string">
1074                <Description>Defines the type of the assembly. One of (nominal scaled
1075                    constraint) "Physical" or "Logical". Physical: the components of
1076                    the assembly are physically connected or in the same area.
1077                    Logical: the components of the assembly are not necessarily
1078                    physically connected or in the same area.</Description>
1079                <Constraint Name="assemblyType">
1080                    <NominalScaledType>
1081                        <RequiredValue>Physical</RequiredValue>
1082                        <RequiredValue>Logical</RequiredValue>
1083                    </NominalScaledType>
1084                </Constraint>
1085            </Attribute>
1086            <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
1087                <Description>Defines the type of the relationships. One of (nominal
1088                    scaled constraint) "Permanent" or "Transient". Permanent: an
1089                    assembly that is not intended to be split during the production
1090                    process. Transient: a temporary assembly used during production,
1091                    such as a pallet of different materials or a batch
1092                    kit.</Description>
1093                <Constraint Name="assemblyRelationship">
1094                    <NominalScaledType>
1095                        <RequiredValue>Permanent</RequiredValue>
1096                        <RequiredValue>Transient</RequiredValue>
1097                    </NominalScaledType>
1098                </Constraint>
1099            </Attribute>
1100        </RoleClass>
1101        <RoleClass Name="RequestedSegmentResponse" RefBaseClassPath="Process">
1102            <Description>
1103                Role class used for requested segment responses.
1104            </Description>
1105            <Attribute Name="id" AttributeDataType="xs:string">
1106                <Description>
1107                    Uniquely identifies the instance of a process segment executed.
1108                </Description>
1109            </Attribute>
1110            <Attribute Name="operationsType" AttributeDataType="xs:string">
1111                <Description>Describes the category of operations. One of (nominal
1112                    scaled constraint) "Production", "Maintenance", "Quality",
1113                    "Inventory", or "Mixed". "Mixed" shall be used when the
```

```
1114                    operations response contains several categories of segment
1115                    responses.</Description>
1116               <Constraint Name="operationsType">
1117                  <NominalScaledType>
1118                     <RequiredValue>Production</RequiredValue>
1119                     <RequiredValue>Maintenance</RequiredValue>
1120                     <RequiredValue>Quality</RequiredValue>
1121                     <RequiredValue>Inventory</RequiredValue>
1122                     <RequiredValue>Mixed</RequiredValue>
1123                  </NominalScaledType>
1124               </Constraint>
1125            </Attribute>
1126            <Attribute Name="actualStartTime" AttributeDataType="xs:dateTime">
1127               <Description>
1128                  The actual start time of this segment response.
1129               </Description>
1130            </Attribute>
1131            <Attribute Name="actualEndTime" AttributeDataType="xs:dateTime">
1132               <Description>
1133                  The actual end time of this segment response.
1134               </Description>
1135            </Attribute>
1136            <Attribute Name="segmentState" AttributeDataType="xs:string">
1137               <Description>Indicates the state of the segment response. One of
1138                  (nominal scaled constraint) "Ready", "Completed", "Aborted", or
1139                  "Holding".</Description>
1140            </Attribute>
1141         </RoleClass>
1142      </RoleClass>
1143      <RoleClass Name="OperationsPerformanceModel" RefBaseClassPath="BR">
1144         <Description>
1145            Abstract role class used for structuring operations performance roles.
1146         </Description>
1147         <RoleClass Name="OperationsPerformance" RefBaseClassPath="ProcessStructure">
1148            <Description>Role class used for operations performances.</Description>
1149            <Attribute Name="id" AttributeDataType="xs:string">
1150               <Description>
1151                  Uniquely identifies the operations performance and could include
1152                  version and revision identification.
1153               </Description>
1154            </Attribute>
1155            <Attribute Name="operationsType" AttributeDataType="xs:string">
1156               <Description>Describes the category of operation. One of (nominal
1157                  scaled constraint) "Production", "Maintenance", "Quality",
1158                  "Inventory", or "Mixed". "Mixed" shall be used when the
1159                  operations performance contains several categories of operations
1160                  responses and/or segment responses.</Description>
1161               <Constraint Name="operationsType">
1162                  <NominalScaledType>
1163                     <RequiredValue>Production</RequiredValue>
1164                     <RequiredValue>Maintenance</RequiredValue>
1165                     <RequiredValue>Quality</RequiredValue>
1166                     <RequiredValue>Inventory</RequiredValue>
1167                     <RequiredValue>Mixed</RequiredValue>
1168                  </NominalScaledType>
1169               </Constraint>
1170            </Attribute>
1171            <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1172               <Description>
1173                  The starting time for the associated operations performance, if
1174                  applicable.
1175               </Description>
1176            </Attribute>
1177            <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1178               <Description>
1179                  The ending time for the associated operations performance, if
```

```
1180                applicable.
1181            </Description>
1182        </Attribute>
1183        <Attribute Name="performanceState" AttributeDataType="xs:string">
1184            <Description>Indicates the state of the operations performance. One of
1185                (nominal scaled constraint) "Ready", "Completed", "Aborted", or
1186                "Holding".</Description>
1187            <Constraint Name="performanceState">
1188                <NominalScaledType>
1189                    <RequiredValue>Ready</RequiredValue>
1190                    <RequiredValue>Completed</RequiredValue>
1191                    <RequiredValue>Aborted</RequiredValue>
1192                    <RequiredValue>Holding</RequiredValue>
1193                </NominalScaledType>
1194            </Constraint>
1195        </Attribute>
1196        <Attribute Name="publishedDate" AttributeDataType="xs:dateTime">
1197            <Description>
1198            The date and time on which the operations performance was published
1199            or generated.
1200            </Description>
1201        </Attribute>
1202    </RoleClass>
1203    <RoleClass Name="OperationsResponse" RefBaseClassPath="ProcessStructure">
1204        <Description>Role class used for operations responses.</Description>
1205        <Attribute Name="id" AttributeDataType="xs:string">
1206            <Description>Uniquely identifies the operations response.</Description>
1207        </Attribute>
1208        <Attribute Name="operationsType" AttributeDataType="xs:string">
1209            <Description>Describes the category of operation. One of (nominal
1210                scaled constraint) "Production", "Maintenance", "Quality",
1211                "Inventory", or "Mixed". "Mixed" shall be used when the
1212                operations response contains several categories of segment
1213                responses.</Description>
1214            <Constraint Name="operationsType">
1215                <NominalScaledType>
1216                    <RequiredValue>Production</RequiredValue>
1217                    <RequiredValue>Maintenance</RequiredValue>
1218                    <RequiredValue>Quality</RequiredValue>
1219                    <RequiredValue>Inventory</RequiredValue>
1220                    <RequiredValue>Mixed</RequiredValue>
1221                </NominalScaledType>
1222            </Constraint>
1223        </Attribute>
1224        <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1225            <Description>
1226            The starting time of this operations response.
1227            </Description>
1228        </Attribute>
1229        <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1230            <Description>The ending time of this operations response.</Description>
1231        </Attribute>
1232        <Attribute Name="responseState" AttributeDataType="xs:string">
1233            <Description>Indicates the state of the operations response. One of
1234                (nominal scaled constraint) "Ready", "Completed", "Aborted", or
1235                "Holding".</Description>
1236            <Constraint Name="responseState">
1237                <NominalScaledType>
1238                    <RequiredValue>Ready</RequiredValue>
1239                    <RequiredValue>Completed</RequiredValue>
1240                    <RequiredValue>Aborted</RequiredValue>
1241                    <RequiredValue>Holding</RequiredValue>
1242                </NominalScaledType>
1243            </Constraint>
1244        </Attribute>
1245    </RoleClass>
```

```
1246        <RoleClass Name="SegmentResponse" RefBaseClassPath="Process">
1247           <Description>Role class used for segment responses.</Description>
1248           <Attribute Name="id" AttributeDataType="xs:string">
1249              <Description>
1250                 Uniquely identifies the instance of a process segment executed.
1251              </Description>
1252           </Attribute>
1253           <Attribute Name="operationsType" AttributeDataType="xs:string">
1254              <Description>Describes the category of operations. One of (nominal
1255                    scaled constraint) "Production", "Maintenance", "Quality",
1256                    "Inventory", or "Mixed". "Mixed" shall be used when the
1257                    operations response contains several categories of segment
1258                    responses.</Description>
1259              <Constraint Name="operationsType">
1260                 <NominalScaledType>
1261                    <RequiredValue>Production</RequiredValue>
1262                    <RequiredValue>Maintenance</RequiredValue>
1263                    <RequiredValue>Quality</RequiredValue>
1264                    <RequiredValue>Inventory</RequiredValue>
1265                    <RequiredValue>Mixed</RequiredValue>
1266                 </NominalScaledType>
1267              </Constraint>
1268           </Attribute>
1269           <Attribute Name="actualStartTime" AttributeDataType="xs:dateTime">
1270              <Description>
1271                 The actual start time of this segment response.
1272              </Description>
1273           </Attribute>
1274           <Attribute Name="actualEndTime" AttributeDataType="xs:dateTime">
1275              <Description>
1276                 The actual end time of this segment response.
1277              </Description>
1278           </Attribute>
1279           <Attribute Name="segmentState" AttributeDataType="xs:string">
1280              <Description>Indicates the state of the segment response. One of
1281                    (nominal scaled constraint) "Ready", "Completed", "Aborted", or
1282                    "Holding".</Description>
1283              <Constraint Name="segmentState">
1284                 <NominalScaledType>
1285                    <RequiredValue>Ready</RequiredValue>
1286                    <RequiredValue>Completed</RequiredValue>
1287                    <RequiredValue>Aborted</RequiredValue>
1288                    <RequiredValue>Holding</RequiredValue>
1289                 </NominalScaledType>
1290              </Constraint>
1291           </Attribute>
1292        </RoleClass>
1293        <RoleClass Name="PersonnelActual" RefBaseClassPath="BR">
1294           <Description>Role class used for personnel actual.</Description>
1295           <Attribute Name="personnelUse" AttributeDataType="xs:string">
1296              <Description>
1297                 Defines the actual use of the personnel class or person.
1298              </Description>
1299           </Attribute>
1300           <Attribute Name="quantity" AttributeDataType="xs:decimal">
1301              <Description>
1302                 Specifies the amount of personnel resources used in the parent
1303                 segment, if applicable. Applies to each member of the person
1304                 or personnel class sets.
1305              </Description>
1306           </Attribute>
1307        </RoleClass>
1308        <RoleClass Name="EquipmentActual" RefBaseClassPath="BR">
1309           <Description>Role class used for equipment actual.</Description>
1310           <Attribute Name="equipmentUse" AttributeDataType="xs:string">
1311              <Description>
```

```
1312                    Defines the actual use of the equipment class or equipment.
1313                </Description>
1314            </Attribute>
1315            <Attribute Name="quantity" AttributeDataType="xs:decimal">
1316                <Description>
1317                    Specifies the amount of equipment resources used in the parent
1318                    segment, if applicable. Applies to each member of the
1319                    equipment or equipment class sets.
1320                </Description>
1321            </Attribute>
1322        </RoleClass>
1323        <RoleClass Name="PhysicalAssetActual" RefBaseClassPath="BR">
1324            <Description>Role class used for physical asset actual.</Description>
1325            <Attribute Name="physicalAssetUse" AttributeDataType="xs:string">
1326                <Description>Defines the actual use of the physical asset class or
1327                    physical asset. Example for maintenance: Repaired, Removed,
1328                    Replacement, Calibrated, Modified/Improved.</Description>
1329            </Attribute>
1330            <Attribute Name="quantity" AttributeDataType="xs:decimal">
1331                <Description>
1332                    Specifies the amount of physical asset resources used in the parent
1333                    segment, if applicable. Applies to each member of the physical
1334                    asset or physical asset class sets.
1335                </Description>
1336            </Attribute>
1337        </RoleClass>
1338        <RoleClass Name="MaterialActual" RefBaseClassPath="BR">
1339            <Description>Role class used for material actual.</Description>
1340            <Attribute Name="materialUse" AttributeDataType="xs:string">
1341                <Description>Defines the actual use of the material. One of (nominal
1342                    scaled constraint) "Consumable", "Consumed", "Produced",
1343                    "Replaced Asset", "Replacement Asset", "Sample", "Returned
1344                    Sample", "Carrier", "Returned Carrier". Defined values for
1345                    production operations: Consumable, Consumed, Produced. Defined
1346                    values for maintenance operations: Consumable, Replaced Asset,
1347                    Replacement Asset. Defined values for quality operations:
1348                    Consumable, Sample, Returned Sample. Defined values for inventory
1349                    operations: Consumable, Carrier, Returned Carrier.</Description>
1350                <Constraint Name="materialUse">
1351                    <NominalScaledType>
1352                        <RequiredValue>Consumable</RequiredValue>
1353                        <RequiredValue>Consumed</RequiredValue>
1354                        <RequiredValue>Produced</RequiredValue>
1355                        <RequiredValue>Replaced Asset</RequiredValue>
1356                        <RequiredValue>Sample</RequiredValue>
1357                        <RequiredValue>Returned Sample</RequiredValue>
1358                        <RequiredValue>Carrier</RequiredValue>
1359                        <RequiredValue>Returned Carrier</RequiredValue>
1360                    </NominalScaledType>
1361                </Constraint>
1362            </Attribute>
1363            <Attribute Name="storageLocation" AttributeDataType="xs:string">
1364                <Description>
1365                    Identifies the actual location of the produced material, if
1366                    applicable.
1367                </Description>
1368            </Attribute>
1369            <Attribute Name="quantity" AttributeDataType="xs:decimal">
1370                <Description>
1371                    Specifies the amount of material produced by the parent segment.
1372                    Applies to each member of the material lot, material
1373                    definition, or material class sets.
1374                </Description>
1375            </Attribute>
1376            <Attribute Name="assemblyType" AttributeDataType="xs:string">
1377                <Description>Defines the type of the assembly. One of (nominal scaled
```

```
1378                constraint) "Physical" or "Logical". Physical: components of the
1379                assembly are physically connected or in the same area. Logical:
1380                components of the assembly are not necessarily physically
1381                connected or in the same area.</Description>
1382            <Constraint Name="assemblyType">
1383               <NominalScaledType>
1384                  <RequiredValue>Physical</RequiredValue>
1385                  <RequiredValue>Logical</RequiredValue>
1386               </NominalScaledType>
1387            </Constraint>
1388         </Attribute>
1389         <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
1390            <Description>Defines the type of the relationships. One of (nominal
1391                scaled constraint) "Permanent" or "Transient". Permanent: an
1392                assembly that is not intended to be split during the production
1393                process. Transient: a temporary assembly used during production,
1394                such as a pallet of different materials or a batch
1395                kit.</Description>
1396            <Constraint Name="assemblyRelationship">
1397               <NominalScaledType>
1398                  <RequiredValue>Permanent</RequiredValue>
1399                  <RequiredValue>Transient</RequiredValue>
1400               </NominalScaledType>
1401            </Constraint>
1402         </Attribute>
1403      </RoleClass>
1404   </RoleClass>
1405   <RoleClass Name="OperationsCapabilityModel" RefBaseClassPath="BR">
1406      <Description>
1407         Abstract role class used for structuring operations capability roles.
1408      </Description>
1409      <RoleClass Name="OperationsCapability" RefBaseClassPath="Process">
1410         <Description>Role class used for operations capabilities.</Description>
1411         <Attribute Name="id" AttributeDataType="xs:string">
1412            <Description>
1413               Defines a unique instance of an operations capability for a
1414               specified element of the equipment hierarchy model
1415               (enterprise, site, area, work center, or work unit).
1416            </Description>
1417         </Attribute>
1418         <Attribute Name="capacityType" AttributeDataType="xs:string">
1419            <Description>The capacity type. One of (nominal scaled constraint)
1420                "Used", "Unused", "Total", "Available", "Unattainable", or
1421                "Committed".</Description>
1422            <Constraint Name="capacityType">
1423               <NominalScaledType>
1424                  <RequiredValue>Used</RequiredValue>
1425                  <RequiredValue>Unused</RequiredValue>
1426                  <RequiredValue>Total</RequiredValue>
1427                  <RequiredValue>Available</RequiredValue>
1428                  <RequiredValue>Unattainable</RequiredValue>
1429                  <RequiredValue>Committed</RequiredValue>
1430               </NominalScaledType>
1431            </Constraint>
1432         </Attribute>
1433         <Attribute Name="reason" AttributeDataType="xs:string">
1434            <Description>Defines the reason for the capability type.</Description>
1435         </Attribute>
1436         <Attribute Name="confidenceFactor" AttributeDataType="xs:string">
1437            <Description>
1438               A measure of the confidence of the capacity value.
1439            </Description>
1440         </Attribute>
1441         <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1442            <Description>
1443               The starting date and time of the operations capability.
```

```
1444                    </Description>
1445                </Attribute>
1446                <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1447                    <Description>
1448                        The ending date and time of the operations capability.
1449                    </Description>
1450                </Attribute>
1451                <Attribute Name="publishedDate" AttributeDataType="xs:dateTime">
1452                    <Description>
1453                        The date and time on which the operations capability was published
1454                        or generated.
1455                    </Description>
1456                </Attribute>
1457            </RoleClass>
1458            <RoleClass Name="PersonnelCapability" RefBaseClassPath="BR">
1459                <Description>Role class used for personnel capabilities.</Description>
1460                <Attribute Name="capabilityType" AttributeDataType="xs:string">
1461                    <Description>The capability type. One of (nominal scaled constraint)
1462                        "Used", "Unused", "Total", "Available", "Unattainable", or
1463                        "Committed".</Description>
1464                    <Constraint Name="capabilityType">
1465                        <NominalScaledType>
1466                            <RequiredValue>Used</RequiredValue>
1467                            <RequiredValue>Unused</RequiredValue>
1468                            <RequiredValue>Total</RequiredValue>
1469                            <RequiredValue>Available</RequiredValue>
1470                            <RequiredValue>Unattainable</RequiredValue>
1471                            <RequiredValue>Committed</RequiredValue>
1472                        </NominalScaledType>
1473                    </Constraint>
1474                </Attribute>
1475                <Attribute Name="reason" AttributeDataType="xs:string">
1476                    <Description>Defines the reason for the capability type.</Description>
1477                </Attribute>
1478                <Attribute Name="confidenceFactor" AttributeDataType="xs:string">
1479                    <Description>
1480                        A measure of the confidence of the capacity value.
1481                    </Description>
1482                </Attribute>
1483                <Attribute Name="personnelUse" AttributeDataType="xs:string">
1484                    <Description>
1485                        Defines the expected capability use of the personnel class or
1486                        person.
1487                    </Description>
1488                </Attribute>
1489                <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1490                    <Description>
1491                        The starting time associated with the personnel capability.
1492                    </Description>
1493                </Attribute>
1494                <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1495                    <Description>
1496                        The ending time associated with the personnel capability.
1497                    </Description>
1498                </Attribute>
1499                <Attribute Name="quantity" AttributeDataType="xs:decimal">
1500                    <Description>
1501                        Specifies the quantity of the personnel capability defined, if
1502                        applicable.
1503                    </Description>
1504                </Attribute>
1505            </RoleClass>
1506            <RoleClass Name="EquipmentCapability" RefBaseClassPath="BR">
1507                <Description>Role class used for equipment capabilities.</Description>
1508                <Attribute Name="capabilityType" AttributeDataType="xs:string">
1509                    <Description>The capability type. One of (nominal scaled constraint)
```

```
1510                    "Used", "Unused", "Total", "Available", "Unattainable", or
1511                    "Committed".</Description>
1512            <Constraint Name="capabilityType">
1513                <NominalScaledType>
1514                    <RequiredValue>Used</RequiredValue>
1515                    <RequiredValue>Unused</RequiredValue>
1516                    <RequiredValue>Total</RequiredValue>
1517                    <RequiredValue>Available</RequiredValue>
1518                    <RequiredValue>Unattainable</RequiredValue>
1519                    <RequiredValue>Committed</RequiredValue>
1520                </NominalScaledType>
1521            </Constraint>
1522        </Attribute>
1523        <Attribute Name="reason" AttributeDataType="xs:string">
1524            <Description>Defines the reason for the capability type.</Description>
1525        </Attribute>
1526        <Attribute Name="confidenceFactor" AttributeDataType="xs:string">
1527            <Description>
1528                A measure of the confidence of the capacity value.
1529            </Description>
1530        </Attribute>
1531        <Attribute Name="equipmentUse" AttributeDataType="xs:string">
1532            <Description>
1533                Defines the expected capability use of the equipment class or
1534                equipment.
1535            </Description>
1536        </Attribute>
1537        <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1538            <Description>
1539                The starting time associated with the equipment capability.
1540            </Description>
1541        </Attribute>
1542        <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1543            <Description>
1544                The ending time associated with the equipment capability.
1545            </Description>
1546        </Attribute>
1547        <Attribute Name="quantity" AttributeDataType="xs:decimal">
1548            <Description>
1549                Specifies the quantity of the equipment capability defined, if
1550                applicable.
1551            </Description>
1552        </Attribute>
1553    </RoleClass>
1554    <RoleClass Name="PhysicalAssetCapability" RefBaseClassPath="BR">
1555        <Description>
1556            Role class used for physical asset capabilities.
1557        </Description>
1558        <Attribute Name="capabilityType" AttributeDataType="xs:string">
1559            <Description>The capability type. One of (nominal scaled constraint)
1560                    "Used", "Unused", "Total", "Available", "Unattainable", or
1561                    "Committed".</Description>
1562            <Constraint Name="capabilityType">
1563                <NominalScaledType>
1564                    <RequiredValue>Used</RequiredValue>
1565                    <RequiredValue>Unused</RequiredValue>
1566                    <RequiredValue>Total</RequiredValue>
1567                    <RequiredValue>Available</RequiredValue>
1568                    <RequiredValue>Unattainable</RequiredValue>
1569                    <RequiredValue>Committed</RequiredValue>
1570                </NominalScaledType>
1571            </Constraint>
1572        </Attribute>
1573        <Attribute Name="reason" AttributeDataType="xs:string">
1574            <Description>Defines the reason for the capability type.</Description>
1575        </Attribute>
```

```
1576            <Attribute Name="confidenceFactor" AttributeDataType="xs:string">
1577                <Description>
1578                    A measure of the confidence of the capacity value.
1579                </Description>
1580            </Attribute>
1581            <Attribute Name="physicalAssetUse" AttributeDataType="xs:string">
1582                <Description>
1583                    Defines the expected capability use of the physical asset class or
1584                    physical asset.
1585                </Description>
1586            </Attribute>
1587            <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1588                <Description>
1589                    The starting time associated with the physical asset capability.
1590                </Description>
1591            </Attribute>
1592            <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1593                <Description>
1594                    The ending time associated with the physical asset capability.
1595                </Description>
1596            </Attribute>
1597            <Attribute Name="quantity" AttributeDataType="xs:decimal">
1598                <Description>
1599                    Specifies the quantity of the physical asset capability defined, if
1600                    applicable.
1601                </Description>
1602            </Attribute>
1603        </RoleClass>
1604        <RoleClass Name="MaterialCapability" RefBaseClassPath="BR">
1605            <Description>Role class used for material capabilities.</Description>
1606            <Attribute Name="capabilityType" AttributeDataType="xs:string">
1607                <Description>The capability type. One of (nominal scaled constraint)
1608                    "Used", "Unused", "Total", "Available", "Unattainable", or
1609                    "Committed".</Description>
1610                <Constraint Name="capabilityType">
1611                    <NominalScaledType>
1612                        <RequiredValue>Used</RequiredValue>
1613                        <RequiredValue>Unused</RequiredValue>
1614                        <RequiredValue>Total</RequiredValue>
1615                        <RequiredValue>Available</RequiredValue>
1616                        <RequiredValue>Unattainable</RequiredValue>
1617                        <RequiredValue>Committed</RequiredValue>
1618                    </NominalScaledType>
1619                </Constraint>
1620            </Attribute>
1621            <Attribute Name="reason" AttributeDataType="xs:string">
1622                <Description>Defines the reason for the capability type.</Description>
1623            </Attribute>
1624            <Attribute Name="confidenceFactor" AttributeDataType="xs:string">
1625                <Description>
1626                    A measure of the confidence of the capacity value.
1627                </Description>
1628            </Attribute>
1629            <Attribute Name="materialUse" AttributeDataType="xs:string">
1630                <Description>
1631                    Defines the expected capability use of the material.
1632                </Description>
1633            </Attribute>
1634            <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1635                <Description>
1636                    The starting time associated with the material capability.
1637                </Description>
1638            </Attribute>
1639            <Attribute Name="endTime" AttributeDataType="xs:dateTime">
1640                <Description>
1641                    The ending time associated with the material capability.
```

```
1642                    </Description>
1643                </Attribute>
1644                <Attribute Name="quantity" AttributeDataType="xs:decimal">
1645                    <Description>
1646                        Specifies the quantity of the material capability defined, if
1647                        applicable.
1648                    </Description>
1649                </Attribute>
1650                <Attribute Name="assemblyType" AttributeDataType="xs:string">
1651                    <Description>Defines the type of the assembly. One of (nominal scaled
1652                        constraint) "Physical" or "Logical". Physical: the components of
1653                        the assembly are physically connected or in the same area.
1654                        Logical: the components of the assembly are not necessarily
1655                        physically connected or in the same area.</Description>
1656                    <Constraint Name="assemblyType">
1657                        <NominalScaledType>
1658                            <RequiredValue>Physical</RequiredValue>
1659                            <RequiredValue>Logical</RequiredValue>
1660                        </NominalScaledType>
1661                    </Constraint>
1662                </Attribute>
1663                <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
1664                    <Description>Defines the type of the relationships. One of (nominal
1665                        scaled constraint) "Permanent" or "Transient". Permanent: an
1666                        assembly that is not intended to be split during the production
1667                        process. Transient: a temporary assembly used during production,
1668                        such as a pallet of different materials or a batch
1669                        kit.</Description>
1670                    <Constraint Name="assemblyRelationship">
1671                        <NominalScaledType>
1672                            <RequiredValue>Permanent</RequiredValue>
1673                            <RequiredValue>Transient</RequiredValue>
1674                        </NominalScaledType>
1675                    </Constraint>
1676                </Attribute>
1677            </RoleClass>
1678        </RoleClass>
1679        <RoleClass Name="ProcessSegmentCapability" RefBaseClassPath="Process">
1680            <Description>Role class used for process segment capabilities.</Description>
1681            <Attribute Name="id" AttributeDataType="xs:string">
1682                <Description>
1683                    Defines a unique instance of a process segment capability for a
1684                    specified element of the equipment hierarchy model (enterprise,
1685                    site, area, work center, or work unit).
1686                </Description>
1687            </Attribute>
1688            <Attribute Name="capacityType" AttributeDataType="xs:string">
1689                <Description>The capacity type. One of (nominal scaled constraint)
1690                    "Available", "Unattainable", or "Committed".</Description>
1691                <Constraint Name="capacityType">
1692                    <NominalScaledType>
1693                        <RequiredValue>Available</RequiredValue>
1694                        <RequiredValue>Unattainable</RequiredValue>
1695                        <RequiredValue>Committed</RequiredValue>
1696                    </NominalScaledType>
1697                </Constraint>
1698            </Attribute>
1699            <Attribute Name="reason" AttributeDataType="xs:string">
1700                <Description>Gives the reason for the capacity type.</Description>
1701            </Attribute>
1702            <Attribute Name="startTime" AttributeDataType="xs:dateTime">
1703                <Description>
1704                    The starting time of the time span defining the capacity type.
1705                </Description>
1706            </Attribute>
1707            <Attribute Name="endTime" AttributeDataType="xs:dateTime">
```

```
1708              <Description>
1709                  The ending time of the time span defining the capacity type.
1710              </Description>
1711          </Attribute>
1712      </RoleClass>
1713 </RoleClassLib>
```

Appendix C   AutomationMLIEC62264AttributeTypeLib

Listing 3 depicts the complete source code of the AutomationMLIEC62264AttributeTypeLib. It defines complex attributes for custom properties emerging in IEC 62264 compatible models.

Listing 3: AutomationML IEC 62264 attribute type library.

```
1   <AttributeTypeLib ChangeMode="create" Name="AutomationMLIEC62264AttributeTypeLib">
2       <Version ChangeMode="create">2.0.0</Version>
3       <AttributeType ChangeMode="create" Name="PersonnelClassProperty">
4           <Description ChangeMode="create">
5               User defined attributes for personnel classes. May be tested by the
6               execution of a qualification test specification.
7           </Description>
8           <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
9       </AttributeType>
10      <AttributeType ChangeMode="create" Name="PersonProperty">
11          <Description ChangeMode="create">
12              User defined attributes for persons. May be tested by the execution of a
13              qualification test specification.
14          </Description>
15          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
16      </AttributeType>
17      <AttributeType ChangeMode="create" Name="EquipmentClassProperty">
18          <Description ChangeMode="create">
19              User defined attributes for equipment classes. May be tested by the
20              execution of an equipment capability test specification.
21          </Description>
22          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
23      </AttributeType>
24      <AttributeType ChangeMode="create" Name="EquipmentProperty">
25          <Description ChangeMode="create">
26              User defined attributes for equipment. May be tested by the execution of an
27              equipment capability test specification.
28          </Description>
29          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
30      </AttributeType>
31      <AttributeType ChangeMode="create" Name="PhysicalAssetClassProperty">
32          <Description ChangeMode="create">
33              User defined attributes for physical asset classes. May be tested by the
34              execution of a physical asset capability test specification.
35          </Description>
36          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
37      </AttributeType>
38      <AttributeType ChangeMode="create" Name="PhysicalAssetProperty">
39          <Description ChangeMode="create">
40              User defined attributes for physical assets. May be tested by the execution
41              of a physical asset capability test specification.
42          </Description>
43          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
44      </AttributeType>
45      <AttributeType ChangeMode="create" Name="MaterialClassProperty">
46          <Description ChangeMode="create">
47              User defined attributes for material classes. May be tested by the execution
48              of a material test specification.
49          </Description>
50          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
51      </AttributeType>
52      <AttributeType ChangeMode="create" Name="MaterialDefinitionProperty">
53          <Description ChangeMode="create">
54              User defined attributes for material definitions. May be tested by the
55              execution of a material test specification.
56          </Description>
57          <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
58      </AttributeType>
59      <AttributeType ChangeMode="create" Name="MaterialLotProperty">
```

```
60        <Description ChangeMode="create">
61            User defined attributes for material lots and sublots. May be tested by the
62            execution of a material test specification.
63        </Description>
64        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
65    </AttributeType>
66    <AttributeType ChangeMode="create" Name="ProcessSegmentParameter">
67        <Description ChangeMode="create">
68            Process segment parameters for process segments.
69        </Description>
70        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
71    </AttributeType>
72    <AttributeType ChangeMode="create" Name="PersonnelSegmentSpecificationProperty">
73        <Description ChangeMode="create">
74            User defined attributes for personnel segment specifications.
75        </Description>
76        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
77        <Attribute ChangeMode="create" Name="quantity"
78            AttributeDataType="xs:decimal" />
79    </AttributeType>
80    <AttributeType ChangeMode="create" Name="EquipmentSegmentSpecificationProperty">
81        <Description ChangeMode="create">
82            User defined attributes for equipment segment specifications.
83        </Description>
84        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
85        <Attribute ChangeMode="create" Name="quantity"
86            AttributeDataType="xs:decimal" />
87    </AttributeType>
88    <AttributeType ChangeMode="create"
89            Name="PhysicalAssetSegmentSpecificationProperty">
90        <Description ChangeMode="create">
91            User defined attributes for physical asset segment specifications.
92        </Description>
93        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
94        <Attribute ChangeMode="create" Name="quantity"
95            AttributeDataType="xs:decimal" />
96    </AttributeType>
97    <AttributeType ChangeMode="create" Name="MaterialSegmentSpecificationProperty">
98        <Description ChangeMode="create">
99            User defined attributes for material segment specifications.
100       </Description>
101       <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
102       <Attribute ChangeMode="create" Name="quantity"
103           AttributeDataType="xs:decimal" />
104   </AttributeType>
105   <AttributeType ChangeMode="create" Name="ParameterSpecification">
106       <Description ChangeMode="create">
107           Parameter specification for operations segments.
108       </Description>
109       <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
110   </AttributeType>
111   <AttributeType ChangeMode="create" Name="PersonnelSpecificationProperty">
112       <Description ChangeMode="create">
113           Parameter specification for personnel specifications.
114       </Description>
115       <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
116       <Attribute ChangeMode="create" Name="quantity"
117           AttributeDataType="xs:decimal" />
118   </AttributeType>
119   <AttributeType ChangeMode="create" Name="EquipmentSpecificationProperty">
120       <Description ChangeMode="create">
121           Parameter specification for equipment specifications.
122       </Description>
123       <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
124       <Attribute ChangeMode="create" Name="quantity"
125           AttributeDataType="xs:decimal" />
```

```
126    </AttributeType>
127    <AttributeType ChangeMode="create" Name="PhysicalAssetSpecificationProperty">
128        <Description ChangeMode="create">
129            Parameter specification for physical asset specifications.
130        </Description>
131        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
132        <Attribute ChangeMode="create" Name="quantity"
133            AttributeDataType="xs:decimal" />
134    </AttributeType>
135    <AttributeType ChangeMode="create" Name="MaterialSpecificationProperty">
136        <Description ChangeMode="create">
137            Parameter specification for material specifications.
138        </Description>
139        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
140        <Attribute ChangeMode="create" Name="quantity"
141            AttributeDataType="xs:decimal" />
142    </AttributeType>
143    <AttributeType ChangeMode="create" Name="SegmentParameter">
144        <Description ChangeMode="create">
145            Parameter specification for segment requirements.
146        </Description>
147        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
148    </AttributeType>
149    <AttributeType ChangeMode="create" Name="PersonnelRequirementProperty">
150        <Description ChangeMode="create">
151            Property specification for personnel requirements.
152        </Description>
153        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
154        <Attribute ChangeMode="create" Name="quantity"
155            AttributeDataType="xs:decimal" />
156    </AttributeType>
157    <AttributeType ChangeMode="create" Name="EquipmentRequirementProperty">
158        <Description ChangeMode="create">
159            Property specification for equipment requirements.
160        </Description>
161        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
162        <Attribute ChangeMode="create" Name="quantity"
163            AttributeDataType="xs:decimal" />
164    </AttributeType>
165    <AttributeType ChangeMode="create" Name="PhysicalAssetRequirementProperty">
166        <Description ChangeMode="create">
167            Property specification for physical asset requirements.
168        </Description>
169        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
170        <Attribute ChangeMode="create" Name="quantity"
171            AttributeDataType="xs:decimal" />
172    </AttributeType>
173    <AttributeType ChangeMode="create" Name="MaterialRequirementProperty">
174        <Description ChangeMode="create">
175            Property specification for material requirements.
176        </Description>
177        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
178        <Attribute ChangeMode="create" Name="quantity"
179            AttributeDataType="xs:decimal" />
180    </AttributeType>
181    <AttributeType ChangeMode="create" Name="SegmentData">
182        <Description ChangeMode="create">
183            Data specification for segment responses.
184        </Description>
185        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
186    </AttributeType>
187    <AttributeType ChangeMode="create" Name="PersonnelActualProperty">
188        <Description ChangeMode="create">
189            Property specification for personnel actuals.
190        </Description>
191        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
```

```
192        <Attribute ChangeMode="create" Name="quantity"
193              AttributeDataType="xs:decimal" />
194    </AttributeType>
195    <AttributeType ChangeMode="create" Name="EquipmentActualProperty">
196        <Description ChangeMode="create">
197            Property specification for equipment actuals.
198        </Description>
199        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
200        <Attribute ChangeMode="create" Name="quantity"
201              AttributeDataType="xs:decimal" />
202    </AttributeType>
203    <AttributeType ChangeMode="create" Name="PhysicalAssetActualProperty">
204        <Description ChangeMode="create">
205            Property specification for physical asset actuals.
206        </Description>
207        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
208        <Attribute ChangeMode="create" Name="quantity"
209              AttributeDataType="xs:decimal" />
210    </AttributeType>
211    <AttributeType ChangeMode="create" Name="MaterialActualProperty">
212        <Description ChangeMode="create">
213            Property specification for material actuals.
214        </Description>
215        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
216        <Attribute ChangeMode="create" Name="quantity"
217              AttributeDataType="xs:decimal" />
218    </AttributeType>
219    <AttributeType ChangeMode="create" Name="PersonnelCapabilityProperty">
220        <Description ChangeMode="create">
221            Property specification for personnel capabilities.
222        </Description>
223        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
224        <Attribute ChangeMode="create" Name="quantity"
225              AttributeDataType="xs:decimal" />
226    </AttributeType>
227    <AttributeType ChangeMode="create" Name="EquipmentCapabilityProperty">
228        <Description ChangeMode="create">
229            Property specification for equipment capabilities.
230        </Description>
231        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
232        <Attribute ChangeMode="create" Name="quantity"
233              AttributeDataType="xs:decimal" />
234    </AttributeType>
235    <AttributeType ChangeMode="create" Name="PhysicalAssetCapabilityProperty">
236        <Description ChangeMode="create">
237            Property specification for physical asset capabilities.
238        </Description>
239        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
240        <Attribute ChangeMode="create" Name="quantity"
241              AttributeDataType="xs:decimal" />
242    </AttributeType>
243    <AttributeType ChangeMode="create" Name="MaterialCapabilityProperty">
244        <Description ChangeMode="create">
245            Property specification for material capabilities.
246        </Description>
247        <Attribute ChangeMode="create" Name="id" AttributeDataType="xs:string" />
248        <Attribute ChangeMode="create" Name="quantity"
249              AttributeDataType="xs:decimal" />
250    </AttributeType>
251 </AttributeTypeLib>
```

Appendix D AutomationMLB2MMLRoleClassLib

Listing 4 depicts the complete source code of the AutomationMLB2MMLRoleClassLib.

Listing 4: AutomationML B2MML role class library.

```
1   <RoleClassLib ChangeMode="change" Name="AutomationMLB2MMLRoleClassLib">
2       <Description>B2MML Role Class Library</Description>
3       <Version ChangeMode="change">2.0.0</Version>
4       <RoleClass Name="B2mmlData"
5           RefBaseClassPath=
6               "AutomationMLBaseRoleClassLib/AutomationMLBaseRole/ExternalData">
7       <Description>
8           B2mmlData shall be used in order to reference external B2MML documents.
9       </Description>
10      </RoleClass>
11  </RoleClassLib>
```

Appendix E Examples for Referencing External B2MML Documents

Clauses E.1 and E.2 exemplify the two distinct ways of referencing B2MML data from AML, while Clause E.2 depicts a more complex example taken from IEC 62714-1.

E.1 Referencing a B2MML Document from AML

In this example, an internal element inside an AML document references an element from B2MML by specifying the complete document as the reference target. Listing 5 shows the relevant excerpt (the instance hierarchy) of the AML document that contains an internal element "Turntable". A child internal element is added to this turntable, representing a B2MML document. By applying an external interface of type ExternalDataReference it references the B2MML document "Turntable.b2mml" through the refURI attribute. As the given URI does not contain a fragment part, the root element of the B2MML document is implicitly referenced – in this example an equiment with the ID "Turntable" (cf. Listing 6).

Listing 5: InstanceHierarchy excerpt of document Example-01-B2MML-Document.aml.

```
1   <InstanceHierarchy ChangeMode="change" Name="B2mmlDocument">
2      <Description>
3         Example for referencing an IEC 62264 element represented by a B2MML document.
4      </Description>
5      <Version ChangeMode="change">2.0.0</Version>
6      <InternalElement ID="Turntable" Name="Turntable">
7         <InternalElement ID="TurntableB2mmlDocument" Name="TurntableB2mmlDocument">
8            <ExternalInterface ID="B2mml" Name="B2mml" RefBaseClassPath="EDR">
9               <Attribute ChangeMode="change" Name="MIMEtype"
10                  AttributeDataType="xs:string"
11                  RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
12                  <Value>application/x.b2mml+xml</Value>
13               </Attribute>
14               <Attribute ChangeMode="change" Name="refURI"
15                  AttributeDataType="xs:anyURI"
16                  RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
17                  <Value>./Turntable.b2mml</Value>
18               </Attribute>
19            </ExternalInterface>
20            <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
21         </InternalElement>
22         <SupportedRoleClass RefRoleClassPath="WorkCell" />
23         <RoleRequirements RefBaseRoleClassPath="Equipment" />
24      </InternalElement>
25   </InstanceHierarchy>
```

NOTE: *By omitting the fragment part of the URI, the root element of the given document is referenced.*

NOTE: *Turntable specifies role class "Equipment" – the referenced B2MML element must be of type "Equipment" as well.*

NOTE: *As the internal element specifies role class "Equipment", it must also specify the equipment level by assigning one of the corresponding role classes of the extended role class hierarchy, in this case "WorkCell" is chosen.*

Listing 6 depicts a B2MML document that contains only one element of type equipment identified by the term "Turntable", exhibiting the minimum set of B2MML attributes: ID, Description, and EquipmentLevel.

Listing 6: Contents of document Turntable.b2mml.

```
1   <Equipment xmlns="http://www.mesa.org/xml/B2MML-V0600">
2       <ID>Turntable</ID>
3       <Description>
4           Turns products towards distinct work cells for further production.
5       </Description>
6       <EquipmentLevel>
7           <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
8       </EquipmentLevel>
9   </Equipment>
```

E.2 Referencing a Specific Element within a B2MML Document from AML

In this example, a specific element of a more complex B2MML document is referenced from an AML document with a very simple instance hierarchy containing an internal element named "Turntable". A child internal element within this "Turntable" element resembles a B2MML document, as clarified with the role class B2mmlData. It specifies an ExternalDataReference referencing the element with ID "Turntable" from the B2MML document "Equipment.b2mml", by declaring "./Equipment.b2mml#Turntable" as refURI (cf. Listing 7). The fragment part "Turntable" is the unique ID of an element within the equipment catalog given in Listing 8.

Listing 7: InstanceHierarchy excerpt of document Example-02-B2MML-Element.aml.

```
1   <InstanceHierarchy ChangeMode="change" Name="B2mmlElement">
2       <Description>
3           Example for referencing an IEC 62264 element that is one of many elements
4           within a B2MML document.
5       </Description>
6       <Version ChangeMode="change">2.0.0</Version>
7       <InternalElement Name="Turntable" ID="Turntable">
8           <InternalElement Name="TurntableB2mmlDocument" ID="TurntableB2mmlDocument">
9               <ExternalInterface Name="B2mml" ID="B2mml" RefBaseClassPath="EDR">
10                  <Attribute ChangeMode="change" Name="MIMEType"
11                      AttributeDataType="xs:string"
12                      RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
13                      <Value>application/x.b2mml+xml</Value>
14                  </Attribute>
15                  <Attribute ChangeMode="change" Name="refURI"
16                      AttributeDataType="xs:anyURI"
17                      RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
18                      <Value>./Equipment.b2mml#Turntable</Value>
19                  </Attribute>
20              </ExternalInterface>
21              <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
22          </InternalElement>
23          <SupportedRoleClass RefRoleClassPath="WorkCell" />
24          <RoleRequirements RefBaseRoleClassPath="Equipment" />
25      </InternalElement>
26  </InstanceHierarchy>
```

NOTE: *By providing a fragment part in the URI, the corresponding (sub) element of the given document is referenced.*

Listing 8 depicts a slightly more complex B2MML document "Equipment.b2mml" that contains a sequence of equipment elements within an equipment information root element. Each of the equipment elements provides a unique ID, a Description, and an EquipmentLevel sub element. The string content of the ID sub element is used to reference a specific equipment element.

Listing 8: Contents of document Equipment.b2mml.

```
1   <EquipmentInformation xmlns="http://www.mesa.org/xml/B2MML-V0600">
2       <Equipment>
3           <ID>Conveyer</ID>
4           <Description>Delivers products from one work cell to another.</Description>
5           <EquipmentLevel>
6               <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
7           </EquipmentLevel>
8       </Equipment>
9       <Equipment>
10          <ID>Turntable</ID>
11          <Description>
12              Turns products towards distinct work cells for further production.
13          </Description>
14          <EquipmentLevel>
15              <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
16          </EquipmentLevel>
17      </Equipment>
18      <Equipment>
19          <ID>Robot</ID>
20          <Description>Assembles products from intermediate products.</Description>
21          <EquipmentLevel>
22              <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
23          </EquipmentLevel>
24      </Equipment>
25  </EquipmentInformation>
```

E.3 Process-Product-Resource (PPR)

The following instance builds upon the example given in Clause A.2.6 of IEC 62714-1. The setup is explained in Table 134 and in Figures 25 and 26. The AutomationML document is presented in Listing 9. The relevant B2MML documents are depicted in Listings 10 to 13, resembling respectively Equipment, Physical Assets, Material, and Process Segments.

Product	Wheel	A wheel that is to be attached to a car.
	Car-without-Wheels	A car that has no wheels attached.
	Car-with-Wheels	A car with wheels attached.
Resource	Conveyer-1	Delivers cars without wheels from the product source to the turntable.
	Conveyer-2	Delivers cars without wheels from the turntable to the product drain for finished products.
	Turntable	Turns cars without wheels either towards the product drain for unfinished products or towards Conveyor-2.
	Robot	Assembles wheels to cars without wheels.
Process	Transport-1	Transport-1 is accomplished with Conveyer-1. Cars without wheels are delivered from the product source to the turntable.
	Transport-2	Transport-2 is accomplished with Conveyer-2. Cars without wheels are delivered from the turntable to the robot.
	Transport-3	Transport-3 is accomplished with Conveyer-2. Cars with wheels are delivered from the robot to the product drain for finished products.
	Turn	Turning is accomplished by the turntable that might hold a Car-without-Wheels. Cars without wheels that should be assembled are turned towards Conveyer-2, the ones that should not be further processed are turned towards the product drain for unfinished products.
	Assemble	Assembling is accomplished by the robot, which attaches Wheels to Cars-without-Wheels in order to transform them into Cars-with-Wheels.

Table 134: Setup of the PPR example (from IEC 62714-1).

Figure 25 resembles a shop floor setup, showing the flow of products (material) through the resources. Processes are represented as arrows and indicate the direction of material flow. In Figures 25 and 26 dark gray trapezoid elements depict resources, and light gray stadiums depict products (in Figure 26, additionally, white rectangles depict processes). In Figure 25 white trapezoids resemble resources that are not regarded in detail in this scenario.
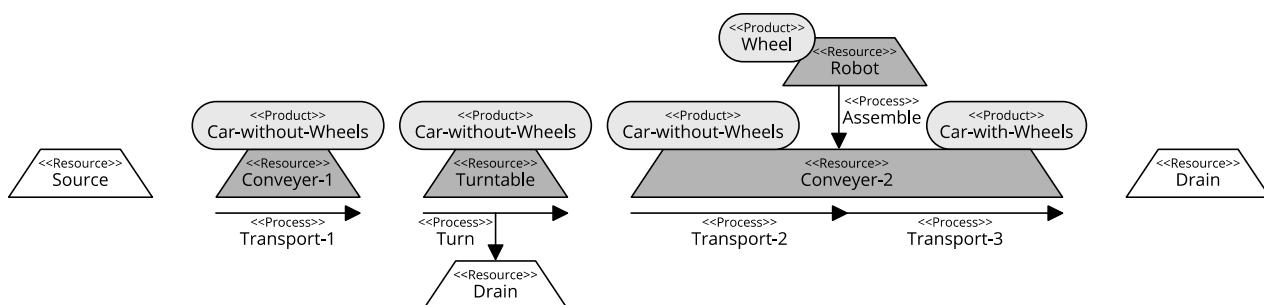

Figure 25: Visualization of the PPR example (from IEC 62714-1).

Figure 26 depicts the complete set of internal links defined for the given scenario. Solid lines connect processes to resources, dotted lines connect processes to products, and dashed lines connect resources to products.
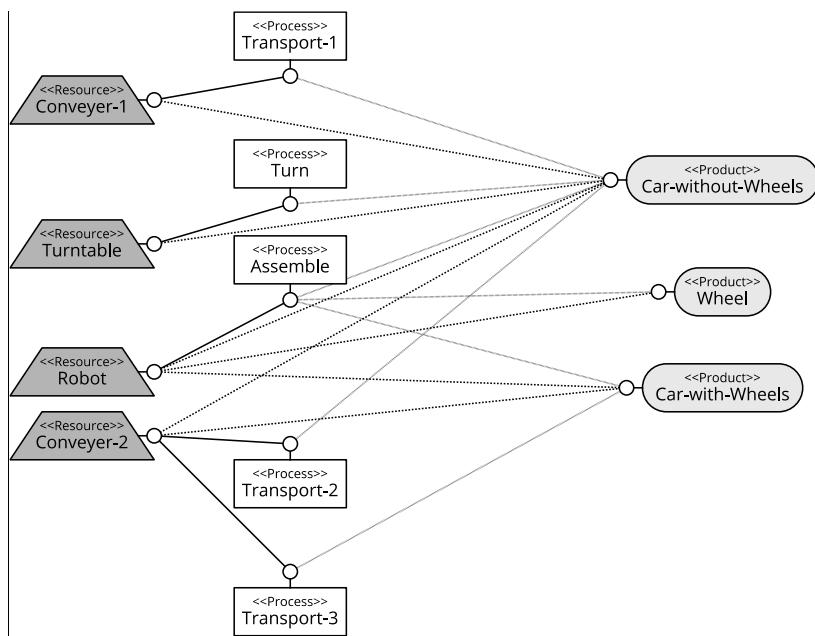
Figure 26: Internal links of the PPR example (from IEC 62714-1).

Listing 9 resembles (i) the InstanceHierarchy, (ii) the RoleClassLib (for material and equipment classes), and (iii) the SystemUnitClassLib (for the material definitions) excerpt of the AutomationML document for the PPR example. It references various elements from different B2MML documents, e.g. the InternalElement with the ID "ID-Conveyer-1" (line 9) references an IEC 62264 equipment encoded in B2MML through an ExternalInterface of type ExternalDataReference (line 13). In lines 17-19, the attribute "refURI" refers to "./PPR-Equipment.b2mml#Conveyer-1", which resolves to the file "PPR-Equipment.b2mml" and the element with ID "Conveyer-1" (cf. Listing 10). In addition, since the equipment in question is of equipment level "WorkCell", in line 24 the corresponding role class "AutomationMLExtendedRoleClassLib/WorkCell" is specified for the InternalElement. The conveyer "Conveyer-1" itself is marked as implementing role class "Equipment" of the AutomationMLIEC62264RoleClassLib. Also, it refers to its equipment class through a supported role class in lines 25-26

Listing 9: InstanceHierarchy, RoleClassLib, and SystemUnitClassLib excerpts of document Example-03-B2MML-PPR.aml.

```
1   <InstanceHierarchy ChangeMode="change" Name="B2MML-PPR-IH">
2       <Description>
3           Example for referencing multiple IEC 62264 elements that reside in multiple
4           B2MML documents that hold multiple B2MML elements. Additionally, AML
5           objects are aligned with PPR roles.
6       </Description>
7       <Version ChangeMode="change">2.0.0</Version>
8       <InternalElement Name="Equipment" ID="Equipment">
9           <InternalElement Name="Conveyer-1" ID="Conveyer-1">
10              <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-11" />
11              <InternalElement Name="Conveyer-1-B2MML-Document"
12                      ID="Conveyer-1-B2MML-Document">
13                  <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-11">
14                      <Attribute Name="MIMEType" AttributeDataType="xs:string"
15                              ChangeMode="change"
16                              RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
17                          <Value>application/x.b2mml+xml</Value>
18                      </Attribute>
19                      <Attribute Name="refURI" AttributeDataType="xs:anyURI"
20                              ChangeMode="change"
21                              RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
22                          <Value>./PPR-Equipment.b2mml#Conveyer-1</Value>
23                      </Attribute>
24                  </ExternalInterface>
```

```
25              <RoleRequirements
26                  RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
27          </InternalElement>
28          <SupportedRoleClass RefRoleClassPath="WorkCell" />
29          <SupportedRoleClass
30              RefRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Conveyer-Class" />
31          <InternalLink Name="C1_CWOW" RefPartnerSideA="Conveyer-1:PPR"
32              RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
33          <RoleRequirements RefBaseRoleClassPath="Equipment" />
34      </InternalElement>
35      <InternalElement Name="Turntable" ID="Turntable">
36          <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-12" />
37          <InternalElement Name="Turntable-B2MML-Document"
38              ID="Turntable-B2MML-Document">
39            <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-12">
40              <Attribute Name="MIMEType" AttributeDataType="xs:string"
41                  ChangeMode="change"
42                  RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
43                <Value>application/x.b2mml+xml</Value>
44              </Attribute>
45              <Attribute Name="refURI" AttributeDataType="xs:anyURI"
46                  ChangeMode="change"
47                  RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
48                <Value>./PPR-Equipment.b2mml#Turntable</Value>
49              </Attribute>
50            </ExternalInterface>
51            <RoleRequirements
52                RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
53          </InternalElement>
54          <SupportedRoleClass RefRoleClassPath="WorkCell" />
55          <SupportedRoleClass
56              RefRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Turntable-Class" />
57          <InternalLink Name="TT_CWOW" RefPartnerSideA="Turntable:PPR"
58              RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
59          <RoleRequirements RefBaseRoleClassPath="Equipment" />
60      </InternalElement>
61      <InternalElement Name="Conveyer-2" ID="Conveyer-2">
62          <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-13" />
63          <InternalElement Name="Conveyer-2-B2MML-Document"
64              ID="Conveyer-2-B2MML-Document">
65            <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-13">
66              <Attribute Name="MIMEType" AttributeDataType="xs:string"
67                  ChangeMode="change"
68                  RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
69                <Value>application/x.b2mml+xml</Value>
70              </Attribute>
71              <Attribute Name="refURI" AttributeDataType="xs:anyURI"
72                  ChangeMode="change"
73                  RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
74                <Value>./PPR-Equipment.b2mml#Conveyer-2</Value>
75              </Attribute>
76            </ExternalInterface>
77            <RoleRequirements
78                RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
79          </InternalElement>
80          <SupportedRoleClass RefRoleClassPath="WorkCell" />
81          <SupportedRoleClass
82              RefRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Conveyer-Class" />
83          <InternalLink Name="C2_CWOW" RefPartnerSideA="Conveyer-2:PPR"
84              RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
85          <InternalLink Name="C2_CWW" RefPartnerSideA="Conveyer-2:PPR"
86              RefPartnerSideB="Car-with-Wheel-Instance:PPR" />
87          <RoleRequirements RefBaseRoleClassPath="Equipment" />
88      </InternalElement>
89      <InternalElement Name="Robot" ID="Robot">
90          <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-14" />
```

```
91          <InternalElement Name="Robot-B2MML-Document" ID="Robot-B2MML-Document">
92              <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-14">
93                  <Attribute Name="MIMEType" AttributeDataType="xs:string"
94                      ChangeMode="change"
95                      RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
96                      <Value>application/x.b2mml+xml</Value>
97                  </Attribute>
98                  <Attribute Name="refURI" AttributeDataType="xs:anyURI"
99                      ChangeMode="change"
100                     RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
101                     <Value>./PPR-Equipment.b2mml#Robot</Value>
102                 </Attribute>
103             </ExternalInterface>
104             <RoleRequirements
105                 RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
106         </InternalElement>
107         <SupportedRoleClass RefRoleClassPath="WorkCell" />
108         <SupportedRoleClass
109             RefRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Robot-Class" />
110         <InternalLink Name="R_CWOW" RefPartnerSideA="Robot:PPR"
111             RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
112         <InternalLink Name="R_W" RefPartnerSideA="Robot:PPR"
113             RefPartnerSideB="Wheel-Instance:PPR" />
114         <InternalLink Name="R_CWW" RefPartnerSideA="Robot:PPR"
115             RefPartnerSideB="Car-with-Wheel-Instance:PPR" />
116         <RoleRequirements RefBaseRoleClassPath="Equipment" />
117     </InternalElement>
118     <RoleRequirements RefBaseRoleClassPath="ResourceStructure" />
119 </InternalElement>
120 <InternalElement Name="EquipmentClasses" ID="EquipmentClasses">
121     <Description>IH representations of "Equipment Class" role
122         classes.</Description>
123     <InternalElement Name="Conveyer-Class" ID="Conveyer-Class">
124         <InternalElement Name="Conveyer-Class-Document"
125             ID="Conveyer-Class-Document">
126             <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-20">
127                 <Attribute Name="MIMEType" AttributeDataType="xs:string"
128                     ChangeMode="change"
129                     RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
130                     <Value>application/x.b2mml+xml</Value>
131                 </Attribute>
132                 <Attribute Name="refURI" AttributeDataType="xs:anyURI"
133                     ChangeMode="change"
134                     RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
135                     <Value>./PPR-Equipment.b2mml#Conveyer-Class</Value>
136                 </Attribute>
137             </ExternalInterface>
138             <RoleRequirements
139                 RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
140         </InternalElement>
141         <RoleRequirements
142             RefBaseRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Conveyer-Class"
143             />
144     </InternalElement>
145     <InternalElement Name="Turntable-Class" ID="Turntable-Class">
146         <InternalElement Name="Turntable-Class-Document"
147             ID="Turntable-Class-Document">
148             <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-21">
149                 <Attribute Name="MIMEType" AttributeDataType="xs:string"
150                     ChangeMode="change"
151                     RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
152                     <Value>application/x.b2mml+xml</Value>
153                 </Attribute>
154                 <Attribute Name="refURI" AttributeDataType="xs:anyURI"
155                     ChangeMode="change"
156                     RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
```

```
157                    <Value>./PPR-Equipment.b2mml#Turntable-Class</Value>
158                </Attribute>
159            </ExternalInterface>
160            <RoleRequirements
161                RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
162        </InternalElement>
163        <RoleRequirements
164            RefBaseRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Turntable-Class"
165            />
166    </InternalElement>
167    <InternalElement Name="Robot-Class" ID="Robot-Class">
168        <InternalElement Name="Robot-Class-Document" ID="Robot-Class-Document">
169            <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-22">
170                <Attribute Name="MIMEType" AttributeDataType="xs:string"
171                    ChangeMode="change"
172                    RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
173                    <Value>application/x.b2mml+xml</Value>
174                </Attribute>
175                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
176                    ChangeMode="change"
177                    RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
178                    <Value>./PPR-Equipment.b2mml#Robot-Class</Value>
179                </Attribute>
180            </ExternalInterface>
181            <RoleRequirements
182                RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
183        </InternalElement>
184        <RoleRequirements
185            RefBaseRoleClassPath="B2MML-PPR-RCL/EquipmentClasses/Robot-Class" />
186    </InternalElement>
187    <RoleRequirements RefBaseRoleClassPath="ResourceStructure" />
188 </InternalElement>
189 <InternalElement Name="PhysicalAssets" ID="PhysicalAssets">
190    <InternalElement Name="Conveyer-1-PA" ID="Conveyer-1-PA"
191        RefBaseSystemUnitPath=
192        "B2MML-PPR-SUC/PhysicalAssetClasses/Short-Conveyer-PA-Class">
193        <Description>
194            Delivers cars without wheels from the product source to the turntable.
195        </Description>
196        <Attribute Name="id" AttributeDataType="xs:string">
197            <Value>Conveyer-1-PA</Value>
198        </Attribute>
199        <Attribute Name="fixedAssetId" AttributeDataType="xs:string">
200            <Value>001</Value>
201        </Attribute>
202        <Attribute Name="vendorId" AttributeDataType="xs:string">
203            <Value>CM12345</Value>
204        </Attribute>
205        <InternalElement Name="Conveyer-1-PA-B2MML-Document"
206            ID="Conveyer-1-PA-B2MML-Document">
207            <ExternalInterface Name="B2MML" ID="B2MML-29" RefBaseClassPath="EDR">
208                <Attribute Name="MIMEType" AttributeDataType="xs:string"
209                    ChangeMode="change"
210                    RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
211                    <Value>application/x.b2mml+xml</Value>
212                </Attribute>
213                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
214                    ChangeMode="change"
215                    RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
216                    <Value>./PPR-PhysicalAssets.b2mml#Conveyer-1-PA</Value>
217                </Attribute>
218            </ExternalInterface>
219            <RoleRequirements
220                RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
221        </InternalElement>
222        <RoleRequirements
```

```
223                RefBaseRoleClassPath=
224                "AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset" />
225        </InternalElement>
226        <InternalElement Name="Turntable-PA" ID="Turntable-PA"
227            RefBaseSystemUnitPath=
228            "B2MML-PPR-SUC/PhysicalAssetClasses/Turntable-PA-Class">
229          <Description>
230            Turns cars without wheels either towards the product drain for unfinished
231            products or towards Conveyor-2.
232          </Description>
233          <Attribute Name="id" AttributeDataType="xs:string">
234            <Value>Turntable-PA</Value>
235          </Attribute>
236          <Attribute Name="fixedAssetId" AttributeDataType="xs:string">
237            <Value>003</Value>
238          </Attribute>
239          <Attribute Name="vendorId" AttributeDataType="xs:string">
240            <Value>TM123</Value>
241          </Attribute>
242          <InternalElement Name="Turntable-PA-B2MML-Document"
243              ID="Turntable-PA-B2MML-Document">
244            <ExternalInterface Name="B2MML" ID="B2MML-26" RefBaseClassPath="EDR">
245              <Attribute Name="MIMEType" AttributeDataType="xs:string"
246                  ChangeMode="change"
247                  RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
248                <Value>application/x.b2mml+xml</Value>
249              </Attribute>
250              <Attribute Name="refURI" AttributeDataType="xs:anyURI"
251                  ChangeMode="change"
252                  RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
253                <Value>./PPR-PhysicalAssets.b2mml#Turntable-PA</Value>
254              </Attribute>
255            </ExternalInterface>
256            <RoleRequirements
257                RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
258          </InternalElement>
259          <RoleRequirements
260              RefBaseRoleClassPath=
261              "AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset" />
262        </InternalElement>
263        <InternalElement Name="Conveyer-2-PA" ID="Conveyer-2-PA"
264            RefBaseSystemUnitPath=
265            "B2MML-PPR-SUC/PhysicalAssetClasses/Long-Conveyer-PA-Class">
266          <Description>
267            Delivers cars without wheels from the turntable to the product drain for
268            finished products.
269          </Description>
270          <Attribute Name="id" AttributeDataType="xs:string">
271            <Value>Conveyer-2-PA</Value>
272          </Attribute>
273          <Attribute Name="fixedAssetId" AttributeDataType="xs:string">
274            <Value>002</Value>
275          </Attribute>
276          <Attribute Name="vendorId" AttributeDataType="xs:string">
277            <Value>CM54321</Value>
278          </Attribute>
279          <InternalElement Name="Conveyer-2-PA-B2MML-Document"
280              ID="Conveyer-2-PA-B2MML-Document">
281            <ExternalInterface Name="B2MML" ID="B2MML-28" RefBaseClassPath="EDR">
282              <Attribute Name="MIMEType" AttributeDataType="xs:string"
283                  ChangeMode="change"
284                  RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
285                <Value>application/x.b2mml+xml</Value>
286              </Attribute>
287              <Attribute Name="refURI" AttributeDataType="xs:anyURI"
288                  ChangeMode="change"
```

```
289                    RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
290                <Value>./PPR-PhysicalAssets.b2mml#Conveyer-2-PA</Value>
291             </Attribute>
292          </ExternalInterface>
293          <RoleRequirements
294             RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
295       </InternalElement>
296       <RoleRequirements
297          RefBaseRoleClassPath=
298          "AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset" />
299    </InternalElement>
300    <InternalElement Name="Robot-PA" ID="Robot-PA"
301       RefBaseSystemUnitPath=
302       "B2MML-PPR-SUC/PhysicalAssetClasses/Robot-PA-Class">
303       <Description>Assembles wheels to cars without wheels.</Description>
304       <Attribute Name="id" AttributeDataType="xs:string">
305          <Value>Robot-PA</Value>
306       </Attribute>
307       <Attribute Name="fixedAssetId" AttributeDataType="xs:string">
308          <Value>004</Value>
309       </Attribute>
310       <Attribute Name="vendorId" AttributeDataType="xs:string">
311          <Value>RM321</Value>
312       </Attribute>
313       <InternalElement Name="Robot-PA-B2MML-Document"
314          ID="Robot-PA-B2MML-Document">
315          <ExternalInterface Name="B2MML" ID="B2MML-27" RefBaseClassPath="EDR">
316             <Attribute Name="MIMEType" AttributeDataType="xs:string"
317                ChangeMode="change"
318                RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
319                <Value>application/x.b2mml+xml</Value>
320             </Attribute>
321             <Attribute Name="refURI" AttributeDataType="xs:anyURI"
322                ChangeMode="change"
323                RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
324                <Value>./PPR-PhysicalAssets.b2mml#Robot-PA</Value>
325             </Attribute>
326          </ExternalInterface>
327          <RoleRequirements
328             RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
329       </InternalElement>
330       <RoleRequirements
331          RefBaseRoleClassPath=
332          "AutomationMLIEC62264RoleClassLib/PhysicalAssetModel/PhysicalAsset" />
333    </InternalElement>
334    <RoleRequirements RefBaseRoleClassPath="ResourceStructure" />
335 </InternalElement>
336 <InternalElement Name="MaterialDefinitions" ID="MaterialDefinitions">
337    <Description>IH representations of "Material Definition" system unit
338       classes.</Description>
339    <InternalElement Name="Wheel" ID="Wheel-Instance"
340       RefBaseSystemUnitPath="B2MML-PPR-SUC/MaterialDefinitions/Wheel">
341       <ExternalInterface Name="PPR" ID="PPR-20" RefBaseClassPath="PPRConnector" />
342       <RoleRequirements RefBaseRoleClassPath="MaterialDefinition" />
343    </InternalElement>
344    <InternalElement Name="Car-without-Wheels" ID="Car-without-Wheels-Instance"
345       RefBaseSystemUnitPath=
346       "B2MML-PPR-SUC/MaterialDefinitions/Car-without-Wheels">
347       <ExternalInterface Name="PPR" ID="PPR-21" RefBaseClassPath="PPRConnector" />
348       <RoleRequirements RefBaseRoleClassPath="MaterialDefinition" />
349    </InternalElement>
350    <InternalElement Name="Car-with-Wheels" ID="Car-with-Wheel-Instance"
351       RefBaseSystemUnitPath=
352       "B2MML-PPR-SUC/MaterialDefinitions/Car-with-Wheels">
353       <ExternalInterface Name="PPR" ID="PPR-22" RefBaseClassPath="PPRConnector" />
354       <RoleRequirements RefBaseRoleClassPath="MaterialDefinition" />
```

```
355        </InternalElement>
356        <RoleRequirements RefBaseRoleClassPath="ProductStructure" />
357    </InternalElement>
358    <InternalElement Name="MaterialClasses" ID="MaterialClasses">
359        <Description>IH representations of "Material Class" role classes.</Description>
360        <InternalElement Name="Car-without-Wheels-Class" ID="Car-without-Wheels-Class">
361            <InternalElement Name="Car-without-Wheels-Class-Document"
362                ID="Car-without-Wheels-Class-Document">
363                <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-23">
364                    <Attribute Name="MIMEType" AttributeDataType="xs:string"
365                        ChangeMode="change"
366                        RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
367                        <Value>application/x.b2mml+xml</Value>
368                    </Attribute>
369                    <Attribute Name="refURI" AttributeDataType="xs:anyURI"
370                        ChangeMode="change"
371                        RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
372                        <Value>./PPR-Material.b2mml#Car-without-Wheels-Class</Value>
373                    </Attribute>
374                </ExternalInterface>
375                <RoleRequirements
376                    RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
377            </InternalElement>
378            <RoleRequirements
379                RefBaseRoleClassPath=
380                "B2MML-PPR-RCL/MaterialClasses/Car-without-Wheels-Class" />
381        </InternalElement>
382        <InternalElement Name="Wheel-Class" ID="Wheel-Class">
383            <InternalElement Name="Wheel-Class-Document" ID="Wheel-Class-Document">
384                <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-24">
385                    <Attribute Name="MIMEType" AttributeDataType="xs:string"
386                        ChangeMode="change"
387                        RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
388                        <Value>application/x.b2mml+xml</Value>
389                    </Attribute>
390                    <Attribute Name="refURI" AttributeDataType="xs:anyURI"
391                        ChangeMode="change"
392                        RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
393                        <Value>./PPR-Material.b2mml#Wheel-Class</Value>
394                    </Attribute>
395                </ExternalInterface>
396                <RoleRequirements
397                    RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
398            </InternalElement>
399            <RoleRequirements
400                RefBaseRoleClassPath="B2MML-PPR-RCL/MaterialClasses/Wheel-Class" />
401        </InternalElement>
402        <InternalElement Name="Car-with-Wheels-Class" ID="Car-with-Wheels-Class">
403            <InternalElement Name="Car-with-Wheels-Class-Document"
404                ID="Car-with-Wheels-Class-Document">
405                <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-25">
406                    <Attribute Name="MIMEType" AttributeDataType="xs:string"
407                        ChangeMode="change"
408                        RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
409                        <Value>application/x.b2mml+xml</Value>
410                    </Attribute>
411                    <Attribute Name="refURI" AttributeDataType="xs:anyURI"
412                        ChangeMode="change"
413                        RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
414                        <Value>./PPR-Material.b2mml#Car-with-Wheels-Class</Value>
415                    </Attribute>
416                </ExternalInterface>
417                <RoleRequirements
418                    RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
419            </InternalElement>
420            <RoleRequirements
```

```
421                RefBaseRoleClassPath=
422                "B2MML-PPR-RCL/MaterialClasses/Car-with-Wheels-Class" />
423         </InternalElement>
424         <RoleRequirements RefBaseRoleClassPath="ProductStructure" />
425     </InternalElement>
426     <InternalElement Name="ProcessSegments" ID="ProcessSegments">
427         <InternalElement Name="Transport-1" ID="Transport-1">
428             <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-15" />
429             <InternalElement Name="Transport-1-B2MML-Document"
430                 ID="Transport-1-B2MML-Document3">
431                 <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-15">
432                     <Attribute Name="MIMEType" AttributeDataType="xs:string"
433                         ChangeMode="change"
434                         RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
435                         <Value>application/x.b2mml+xml</Value>
436                     </Attribute>
437                     <Attribute Name="refURI" AttributeDataType="xs:anyURI"
438                         ChangeMode="change"
439                         RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
440                         <Value>./PPR-ProcessSegments.b2mml#Transport-1</Value>
441                     </Attribute>
442                 </ExternalInterface>
443                 <RoleRequirements
444                     RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
445             </InternalElement>
446             <InternalLink Name="T1_C1" RefPartnerSideA="Transport-1:PPR"
447                 RefPartnerSideB="Conveyer-1:PPR" />
448             <InternalLink Name="T1_CWOW" RefPartnerSideA="Transport-1:PPR"
449                 RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
450             <RoleRequirements RefBaseRoleClassPath="ProcessSegment" />
451         </InternalElement>
452         <InternalElement Name="Turn" ID="Turn">
453             <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-16" />
454             <InternalElement Name="Turn-B2MML-Document" ID="Turn-B2MML-Document">
455                 <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-16">
456                     <Attribute Name="MIMEType" AttributeDataType="xs:string"
457                         ChangeMode="change"
458                         RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
459                         <Value>application/x.b2mml+xml</Value>
460                     </Attribute>
461                     <Attribute Name="refURI" AttributeDataType="xs:anyURI"
462                         ChangeMode="change"
463                         RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
464                         <Value>./PPR-ProcessSegments.b2mml#Turn</Value>
465                     </Attribute>
466                 </ExternalInterface>
467                 <RoleRequirements
468                     RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
469             </InternalElement>
470             <InternalLink Name="T_TT" RefPartnerSideA="Turn:PPR"
471                 RefPartnerSideB="Turntable:PPR" />
472             <InternalLink Name="T_CWOW" RefPartnerSideA="Turn:PPR"
473                 RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
474             <RoleRequirements RefBaseRoleClassPath="ProcessSegment" />
475         </InternalElement>
476         <InternalElement Name="Transport-2" ID="Transport-2">
477             <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-17" />
478             <InternalElement Name="Transport-2-B2MML-Document"
479                 ID="Transport-2-B2MML-Document">
480                 <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-17">
481                     <Attribute Name="MIMEType" AttributeDataType="xs:string"
482                         ChangeMode="change"
483                         RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
484                         <Value>application/x.b2mml+xml</Value>
485                     </Attribute>
486                     <Attribute Name="refURI" AttributeDataType="xs:anyURI"
```

```
487              ChangeMode="change"
488              RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
489          <Value>./PPR-ProcessSegments.b2mml#Transport-2</Value>
490        </Attribute>
491      </ExternalInterface>
492      <RoleRequirements
493          RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
494    </InternalElement>
495    <InternalLink Name="T2_C2" RefPartnerSideA="Transport-2:PPR"
496        RefPartnerSideB="Conveyer-2:PPR" />
497    <InternalLink Name="T2_CWOW" RefPartnerSideA="Transport-2:PPR"
498        RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
499    <RoleRequirements RefBaseRoleClassPath="ProcessSegment" />
500  </InternalElement>
501  <InternalElement Name="Assemble" ID="Assemble">
502    <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-18" />
503    <InternalElement Name="Assemble-B2MML-Document"
504        ID="Assemble-B2MML-Document">
505      <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-18">
506        <Attribute Name="MIMEType" AttributeDataType="xs:string"
507            ChangeMode="change"
508            RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
509          <Value>application/x.b2mml+xml</Value>
510        </Attribute>
511        <Attribute Name="refURI" AttributeDataType="xs:anyURI"
512            ChangeMode="change"
513            RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
514          <Value>./PPR-ProcessSegments.b2mml#Assemble</Value>
515        </Attribute>
516      </ExternalInterface>
517      <RoleRequirements
518          RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
519    </InternalElement>
520    <InternalLink Name="A_R" RefPartnerSideA="Assemble:PPR"
521        RefPartnerSideB="Robot:PPR" />
522    <InternalLink Name="A_CWOW" RefPartnerSideA="Assemble:PPR"
523        RefPartnerSideB="Car-without-Wheels-Instance:PPR" />
524    <InternalLink Name="A_W" RefPartnerSideA="Assemble:PPR"
525        RefPartnerSideB="Wheel-Instance:PPR" />
526    <InternalLink Name="A_CWW" RefPartnerSideA="Assemble:PPR"
527        RefPartnerSideB="Car-with-Wheel-Instance:PPR" />
528    <RoleRequirements RefBaseRoleClassPath="ProcessSegment" />
529  </InternalElement>
530  <InternalElement Name="Transport-3" ID="Transport-3">
531    <ExternalInterface Name="PPR" RefBaseClassPath="PPRConnector" ID="PPR-19" />
532    <InternalElement Name="Transport-3-B2MML-Document"
533        ID="Transport-3-B2MML-Document">
534      <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-19">
535        <Attribute Name="MIMEType" AttributeDataType="xs:string"
536            ChangeMode="change"
537            RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
538          <Value>application/x.b2mml+xml</Value>
539        </Attribute>
540        <Attribute Name="refURI" AttributeDataType="xs:anyURI"
541            ChangeMode="change"
542            RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
543          <Value>./PPR-ProcessSegments.b2mml#Transport-3</Value>
544        </Attribute>
545      </ExternalInterface>
546      <RoleRequirements
547          RefBaseRoleClassPath="AutomationMLB2MMLRoleClassLib/B2mmlData" />
548    </InternalElement>
549    <InternalLink Name="T3_C2" RefPartnerSideA="Transport-3:PPR"
550        RefPartnerSideB="Conveyer-2:PPR" />
551    <InternalLink Name="T3_CWW" RefPartnerSideA="Transport-3:PPR"
552        RefPartnerSideB="Car-with-Wheel-Instance:PPR" />
```

```
553            <RoleRequirements RefBaseRoleClassPath="ProcessSegment" />
554        </InternalElement>
555        <RoleRequirements RefBaseRoleClassPath="ProcessStructure" />
556    </InternalElement>
557 </InstanceHierarchy>
558 <RoleClassLib ChangeMode="change" Name="B2MML-PPR-RCL">
559    <Description>Modeling of IEC 62264 information.</Description>
560    <Version ChangeMode="change">2.0.0</Version>
561    <RoleClass Name="EquipmentClasses" RefBaseClassPath="ResourceStructure">
562        <RoleClass Name="Conveyer-Class"
563            RefBaseClassPath=
564            "AutomationMLIEC62264RoleClassLib/EquipmentModel/EquipmentClass">
565        <Description>
566            Conveyers of all kind belong to the Conveyer equipment class.
567        </Description>
568        <Attribute Name="id" AttributeDataType="xs:string">
569            <Value>Conveyer-Class</Value>
570        </Attribute>
571    </RoleClass>
572    <RoleClass Name="Turntable-Class"
573        RefBaseClassPath=
574        "AutomationMLIEC62264RoleClassLib/EquipmentModel/EquipmentClass">
575        <Description>
576            Turntables of all kind belong to the Turntable equipment class.
577        </Description>
578        <Attribute Name="id" AttributeDataType="xs:string">
579            <Value>Turntable-Class</Value>
580        </Attribute>
581    </RoleClass>
582    <RoleClass Name="Robot-Class"
583        RefBaseClassPath=
584        "AutomationMLIEC62264RoleClassLib/EquipmentModel/EquipmentClass">
585        <Description>
586            Robots of all kind belong to the Robot equipment class.
587        </Description>
588        <Attribute Name="id" AttributeDataType="xs:string">
589            <Value>Robot-Class</Value>
590        </Attribute>
591    </RoleClass>
592    </RoleClass>
593    <RoleClass Name="MaterialClasses" RefBaseClassPath="ProductStructure">
594        <RoleClass Name="Car-without-Wheels-Class"
595            RefBaseClassPath=
596            "AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialClass">
597        <Description>
598            Cars without wheels of all kind belong to the Car-without-Wheels material
599            class.
600        </Description>
601        <Attribute Name="id" AttributeDataType="xs:string">
602            <Value>Car-without-Wheels-Class</Value>
603        </Attribute>
604    </RoleClass>
605    <RoleClass Name="Wheel-Class"
606        RefBaseClassPath=
607        "AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialClass">
608        <Description>
609            Wheels of all kind belong to the Wheel material class.
610        </Description>
611        <Attribute Name="id" AttributeDataType="xs:string">
612            <Value>Wheel-Class</Value>
613        </Attribute>
614    </RoleClass>
615    <RoleClass Name="Car-with-Wheels-Class"
616        RefBaseClassPath=
617        "AutomationMLIEC62264RoleClassLib/MaterialModel/MaterialClass">
618        <Description>
```

```
619            Cars with wheels of all kind belong to the Car-with-Wheels material
620            class.
621         </Description>
622         <Attribute Name="assemblyType" AttributeDataType="xs:string">
623            <Value>Physical</Value>
624         </Attribute>
625         <Attribute Name="assemblyRelationship" AttributeDataType="xs:string">
626            <Value>Permanent</Value>
627         </Attribute>
628         <Attribute Name="id" AttributeDataType="xs:string">
629            <Value>Car-with-Wheels-Class</Value>
630         </Attribute>
631      </RoleClass>
632   </RoleClass>
633 </RoleClassLib>
634 <SystemUnitClassLib ChangeMode="change" Name="B2MML-PPR-SUC">
635    <Description>
636       Integration of IEC 62264 information by referencing B2MML documents.
637    </Description>
638    <Version ChangeMode="change">2.0.0</Version>
639    <SystemUnitClass Name="PhysicalAssetClasses">
640       <SupportedRoleClass RefRoleClassPath="ResourceStructure" />
641       <SystemUnitClass Name="Short-Conveyer-PA-Class" ID="Short-Conveyer-PA-Class">
642          <Description>The short conveyer of Conveyer Manufacturer.</Description>
643          <Attribute Name="id" AttributeDataType="xs:string">
644             <Value>Short-Conveyer-PA-Class</Value>
645          </Attribute>
646          <Attribute Name="manufacturer" AttributeDataType="xs:string">
647             <Value>Conveyer Manufacturer</Value>
648          </Attribute>
649          <InternalElement Name="Short-Conveyer-PA-Class-B2MML-Document"
650                ID="Short-Conveyer-PA-Class-B2MML-Document">
651             <ExternalInterface Name="B2MML" ID="B2MML-07" RefBaseClassPath="EDR">
652                <Attribute Name="MIMEType" AttributeDataType="xs:string"
653                      ChangeMode="change"
654                      RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
655                   <Value>application/x.b2mml+xml</Value>
656                </Attribute>
657                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
658                      ChangeMode="change"
659                      RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
660                   <Value>./PPR-PhysicalAssets.b2mml#Short-Conveyer-PA-Class</Value>
661                </Attribute>
662             </ExternalInterface>
663             <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
664          </InternalElement>
665          <SupportedRoleClass RefRoleClassPath="PhysicalAssetClass" />
666       </SystemUnitClass>
667       <SystemUnitClass Name="Long-Conveyer-PA-Class" ID="Long-Conveyer-PA-Class">
668          <Description>The long conveyer of Conveyer Manufacturer.</Description>
669          <Attribute Name="id" AttributeDataType="xs:string">
670             <Value>Long-Conveyer-PA-Class</Value>
671          </Attribute>
672          <Attribute Name="manufacturer" AttributeDataType="xs:string">
673             <Value>Conveyer Manufacturer</Value>
674          </Attribute>
675          <InternalElement Name="Long-Conveyer-PA-Class-B2MML-Document"
676                ID="Long-Conveyer-PA-Class-B2MML-Document">
677             <ExternalInterface Name="B2MML" ID="B2MML-04" RefBaseClassPath="EDR">
678                <Attribute Name="MIMEType" AttributeDataType="xs:string"
679                      ChangeMode="change"
680                      RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
681                   <Value>application/x.b2mml+xml</Value>
682                </Attribute>
683                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
684                      ChangeMode="change"
```

```
685                         RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
686                     <Value>./PPR-PhysicalAssets.b2mml#Long-Conveyer-PA-Class</Value>
687                 </Attribute>
688             </ExternalInterface>
689             <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
690         </InternalElement>
691         <SupportedRoleClass RefRoleClassPath="PhysicalAssetClass" />
692     </SystemUnitClass>
693     <SystemUnitClass Name="Turntable-PA-Class" ID="Turntable-PA-Class">
694         <Description>The high end turntable of Turntable Manufacturer.</Description>
695         <Attribute Name="id" AttributeDataType="xs:string">
696             <Value>Turntable-PA-Class</Value>
697         </Attribute>
698         <Attribute Name="manufacturer" AttributeDataType="xs:string">
699             <Value>Turntable Manufacturer</Value>
700         </Attribute>
701         <InternalElement Name="Turntable-PA-Class-B2MML-Document"
702                 ID="Turntable-PA-Class-B2MML-Document">
703             <ExternalInterface Name="B2MML" ID="B2MML-05" RefBaseClassPath="EDR">
704                 <Attribute Name="MIMEType" AttributeDataType="xs:string"
705                         ChangeMode="change"
706                         RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
707                     <Value>application/x.b2mml+xml</Value>
708                 </Attribute>
709                 <Attribute Name="refURI" AttributeDataType="xs:anyURI"
710                         ChangeMode="change"
711                         RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
712                     <Value>./PPR-PhysicalAssets.b2mml#Turntable-PA-Class</Value>
713                 </Attribute>
714             </ExternalInterface>
715             <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
716         </InternalElement>
717         <SupportedRoleClass RefRoleClassPath="PhysicalAssetClass" />
718     </SystemUnitClass>
719     <SystemUnitClass Name="Robot-PA-Class" ID="Robot-PA-Class">
720         <Description>The only robot of Robot Manufacturer.</Description>
721         <Attribute Name="id" AttributeDataType="xs:string">
722             <Value>Robot-PA-Class</Value>
723         </Attribute>
724         <Attribute Name="manufacturer" AttributeDataType="xs:string">
725             <Value>Robot Manufacturer</Value>
726         </Attribute>
727         <InternalElement Name="Robot-PA-Class-B2MML-Document"
728                 ID="Robot-PA-Class-B2MML-Document">
729             <ExternalInterface Name="B2MML" ID="B2MML-06" RefBaseClassPath="EDR">
730                 <Attribute Name="MIMEType" AttributeDataType="xs:string"
731                         ChangeMode="change"
732                         RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
733                     <Value>application/x.b2mml+xml</Value>
734                 </Attribute>
735                 <Attribute Name="refURI" AttributeDataType="xs:anyURI"
736                         ChangeMode="change"
737                         RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
738                     <Value>./PPR-PhysicalAssets.b2mml#Robot-PA-Class</Value>
739                 </Attribute>
740             </ExternalInterface>
741             <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
742         </InternalElement>
743         <SupportedRoleClass RefRoleClassPath="PhysicalAssetClass" />
744     </SystemUnitClass>
745 </SystemUnitClass>
746 <SystemUnitClass Name="MaterialDefinitions">
747     <SupportedRoleClass RefRoleClassPath="ProductStructure" />
748     <SystemUnitClass Name="Wheel" ID="Wheel">
749         <InternalElement Name="Wheel-B2MML-Document" ID="Wheel-B2MML-Document">
750             <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-01">
```

```
751                <Attribute Name="MIMEType" AttributeDataType="xs:string"
752                    ChangeMode="change"
753                    RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
754                <Value>application/x.b2mml+xml</Value>
755                </Attribute>
756                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
757                    ChangeMode="change"
758                    RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
759                <Value>./PPR-Material.b2mml#Wheel</Value>
760                </Attribute>
761            </ExternalInterface>
762            <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
763        </InternalElement>
764        <SupportedRoleClass
765            RefRoleClassPath="B2MML-PPR-RCL/MaterialClasses/Wheel-Class" />
766        <SupportedRoleClass RefRoleClassPath="MaterialDefinition" />
767    </SystemUnitClass>
768    <SystemUnitClass Name="Car-without-Wheels" ID="Car-without-Wheels">
769        <InternalElement Name="Car-without-Wheels-B2MML-Document"
770            ID="Car-without-Wheels-B2MML-Document">
771            <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-02">
772                <Attribute Name="MIMEType" AttributeDataType="xs:string"
773                    ChangeMode="change"
774                    RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
775                <Value>application/x.b2mml+xml</Value>
776                </Attribute>
777                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
778                    ChangeMode="change"
779                    RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
780                <Value>./PPR-Material.b2mml#Car-without-Wheels</Value>
781                </Attribute>
782            </ExternalInterface>
783            <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
784        </InternalElement>
785        <SupportedRoleClass
786            RefRoleClassPath=
787            "B2MML-PPR-RCL/MaterialClasses/Car-without-Wheels-Class" />
788        <SupportedRoleClass RefRoleClassPath="MaterialDefinition" />
789    </SystemUnitClass>
790    <SystemUnitClass Name="Car-with-Wheels" ID="Car-with-Wheels">
791        <InternalElement Name="Car-with-Wheels-B2MML-Document"
792            ID="Car-with-Wheels-B2MML-Document">
793            <ExternalInterface Name="B2MML" RefBaseClassPath="EDR" ID="B2MML-03">
794                <Attribute Name="MIMEType" AttributeDataType="xs:string"
795                    ChangeMode="change"
796                    RefAttributeType="AutomationMLBaseAttributeTypeLib/MIMEType">
797                <Value>application/x.b2mml+xml</Value>
798                </Attribute>
799                <Attribute Name="refURI" AttributeDataType="xs:anyURI"
800                    ChangeMode="change"
801                    RefAttributeType="AutomationMLBaseAttributeTypeLib/refURI">
802                <Value>./PPR-Material.b2mml#Car-with-Wheels</Value>
803                </Attribute>
804            </ExternalInterface>
805            <RoleRequirements RefBaseRoleClassPath="B2mmlData" />
806        </InternalElement>
807        <SupportedRoleClass
808            RefRoleClassPath="B2MML-PPR-RCL/MaterialClasses/Car-with-Wheels-Class"
809            />
810        <SupportedRoleClass RefRoleClassPath="MaterialDefinition" />
811    </SystemUnitClass>
812  </SystemUnitClass>
813 </SystemUnitClassLib>
```

Listing 10 depicts the IEC 62264 equipment information encoded in B2MML. Equipment is one of two possible IEC 62264 counterparts of AML resources (the other one being physical assets). In order to list several pieces of equipment in one document, the root element EquipmentInformation is to be used. In this case, three equipment classes are specified: "Conveyer-Class", "Turntable-Class", and "Robot-Class". Each of the classes specifies a list of equipment that is defined by this equipment class in a sequence of EquipmentID elements. Equipment elements in turn define through the EquipmentClassID element to which equipment class they belong to.

Listing 10: Contents of document PPR-Equipment.b2mml.

```
1   <EquipmentInformation xmlns="http://www.mesa.org/xml/B2MML-V0600">
2       <Equipment>
3           <ID>Conveyer-1</ID>
4           <Description>
5               Delivers cars without wheels from the product source to the turntable.
6           </Description>
7           <EquipmentLevel>
8               <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
9           </EquipmentLevel>
10          <EquipmentClassID>Conveyer-Class</EquipmentClassID>
11      </Equipment>
12      <Equipment>
13          <ID>Conveyer-2</ID>
14          <Description>
15              Delivers cars without wheels from the turntable to the product drain for
16              finished products.
17          </Description>
18          <EquipmentLevel>
19              <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
20          </EquipmentLevel>
21          <EquipmentClassID>Conveyer-Class</EquipmentClassID>
22      </Equipment>
23      <Equipment>
24          <ID>Turntable</ID>
25          <Description>
26              Turns cars without wheels either towards the product drain for unfinished
27              products or towards Conveyor2.
28          </Description>
29          <EquipmentLevel>
30              <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
31          </EquipmentLevel>
32          <EquipmentClassID>Turntable-Class</EquipmentClassID>
33      </Equipment>
34      <Equipment>
35          <ID>Robot</ID>
36          <Description>Assembles wheels to cars without wheels.</Description>
37          <EquipmentLevel>
38              <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
39          </EquipmentLevel>
40          <EquipmentClassID>Robot-Class</EquipmentClassID>
41      </Equipment>
42      <EquipmentClass>
43          <ID>Conveyer-Class</ID>
44          <Description>
45              Conveyers of all kind belong to the Conveyer equipment class.
46          </Description>
47          <EquipmentLevel>
48              <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
49          </EquipmentLevel>
50          <EquipmentID>Conveyer-1</EquipmentID>
51          <EquipmentID>Conveyer-2</EquipmentID>
52      </EquipmentClass>
53      <EquipmentClass>
54          <ID>Turntable-Class</ID>
55          <Description>
```

```
56          Turntables of all kind belong to the Turntable equipment class.
57       </Description>
58       <EquipmentLevel>
59          <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
60       </EquipmentLevel>
61       <EquipmentID>Turntable</EquipmentID>
62    </EquipmentClass>
63    <EquipmentClass>
64       <ID>Robot-Class</ID>
65       <Description>
66          Robots of all kind belong to the Robot equipment class.
67       </Description>
68       <EquipmentLevel>
69          <EquipmentElementLevel>WorkCell</EquipmentElementLevel>
70       </EquipmentLevel>
71       <EquipmentID>Robot</EquipmentID>
72    </EquipmentClass>
73 </EquipmentInformation>
```

Listing 11 depicts the IEC 62264 physical asset information encoded in B2MML. Physical assets are one of two possible IEC 62264 counterparts of AML resources (the other one being equipment). In order to list several physical assets in one document, the root element PhysicalAssetModel is to be used. Here, four physical asset classes are defined: one for each equipment class presented in Listing 10 except for the Conveyer-Class, where two physical asset classes are defined, one for long conveyers, and one for short conveyers. The reason for that is the logics defined in IEC 62264: a physical asset class corresponds to a certain product model of a supplier. The four physical assets correspond to the required resources for the PPR example – in IEC 62264 physical assets correspond to a specific instance of a product model, i.e. something that yields a unique serial number.

Listing 11: Contents of document PPR-PhysicalAssets.b2mml.

```
1  <PhysicalAssetInformation xmlns="http://www.mesa.org/xml/B2MML-V0600">
2     <PhysicalAsset>
3        <ID>Conveyer-1-PA</ID>
4        <Description>
5           Delivers cars without wheels from the product source to the turntable.
6        </Description>
7        <PhysicalLocation>Area 1, Hall 1</PhysicalLocation>
8        <FixedAssetID>001</FixedAssetID>
9        <VendorID>CM12345</VendorID>
10       <EquipmentAssetMapping>
11          <EquipmentID>Conveyer-1</EquipmentID>
12          <PhysicalAssetID>Conveyer-1-PA</PhysicalAssetID>
13          <StartTime>2016-06-01</StartTime>
14       </EquipmentAssetMapping>
15       <PhysicalAssetClassID>Short-Conveyer-PA-Class</PhysicalAssetClassID>
16    </PhysicalAsset>
17    <PhysicalAsset>
18       <ID>Conveyer-2-PA</ID>
19       <Description>
20          Delivers cars without wheels from the turntable to the product drain for
21          finished products.
22       </Description>
23       <PhysicalLocation>Area 1, Hall 1</PhysicalLocation>
24       <FixedAssetID>002</FixedAssetID>
25       <VendorID>CM54321</VendorID>
26       <EquipmentAssetMapping>
27          <EquipmentID>Conveyer-2</EquipmentID>
28          <PhysicalAssetID>Conveyer-2-PA</PhysicalAssetID>
29          <StartTime>2016-06-02</StartTime>
30       </EquipmentAssetMapping>
31       <PhysicalAssetClassID>Long- Conveyer-PA-Class</PhysicalAssetClassID>
32    </PhysicalAsset>
33    <PhysicalAsset>
```

```
34          <ID>Turntable-PA</ID>
35          <Description>
36              Turns cars without wheels either towards the product drain for unfinished
37              products or towards Conveyor 2.
38          </Description>
39          <PhysicalLocation>Area 1, Hall 1</PhysicalLocation>
40          <FixedAssetID>003</FixedAssetID>
41          <VendorID>TM123</VendorID>
42          <EquipmentAssetMapping>
43              <EquipmentID>Turntable</EquipmentID>
44              <PhysicalAssetID>Turntable-PA</PhysicalAssetID>
45              <StartTime>2016-06-03</StartTime>
46          </EquipmentAssetMapping>
47          <PhysicalAssetClassID>Turntable-PA-Class</PhysicalAssetClassID>
48      </PhysicalAsset>
49      <PhysicalAsset>
50          <ID>Robot-PA</ID>
51          <Description>Assembles wheels to cars without wheels.</Description>
52          <PhysicalLocation>Area 1, Hall 1</PhysicalLocation>
53          <FixedAssetID>004</FixedAssetID>
54          <VendorID>RM321</VendorID>
55          <EquipmentAssetMapping>
56              <EquipmentID>Robot</EquipmentID>
57              <PhysicalAssetID>Robot-PA</PhysicalAssetID>
58              <StartTime>2016-06-04</StartTime>
59          </EquipmentAssetMapping>
60          <PhysicalAssetClassID>Robot-PA-Class</PhysicalAssetClassID>
61      </PhysicalAsset>
62      <PhysicalAssetClass>
63          <ID>Short-Conveyer-PA-Class</ID>
64          <Description>The short conveyer of Conveyer Manufacturer.</Description>
65          <Manufacturer>Conveyer Manufacturer</Manufacturer>
66          <PhysicalAssetID>Conveyer-1-PA</PhysicalAssetID>
67      </PhysicalAssetClass>
68      <PhysicalAssetClass>
69          <ID>Long-Conveyer-PA-Class</ID>
70          <Description>The long conveyer of Conveyer Manufacturer.</Description>
71          <Manufacturer>Conveyer Manufacturer</Manufacturer>
72          <PhysicalAssetID>Conveyer-2-PA</PhysicalAssetID>
73      </PhysicalAssetClass>
74      <PhysicalAssetClass>
75          <ID>Turntable-PA-Class</ID>
76          <Description>The high end turntable of Turntable Manufacturer.</Description>
77          <Manufacturer>Turntable Manufacturer</Manufacturer>
78          <PhysicalAssetID>Turntable-PA</PhysicalAssetID>
79      </PhysicalAssetClass>
80      <PhysicalAssetClass>
81          <ID>Robot-PA-Class</ID>
82          <Description>The only robot of Robot Manufacturer.</Description>
83          <Manufacturer>Robot Manufacturer</Manufacturer>
84          <PhysicalAssetID>Robot-PA</PhysicalAssetID>
85      </PhysicalAssetClass>
86  </PhysicalAssetInformation>
```

Listing 12 depicts the IEC 62264 material information encoded in B2MML. Material is the IEC 62264 equivalent of AML products. In order to list several types of material in one document, the root element MaterialInformation is to be used. In this example three material classes and three material definitions are defined: cars without wheels, wheels, and cars with wheels. Material may represent an assembly, which can be defined on material class and/or material definition level. In this case, it is defined on both levels, stating that a car with wheels is a physical (the other option would be logical) and permanent (that is, it is not teared apart during production again) assembly of (i) a car without wheels and (ii) wheels.

Listing 12: Contents of document PPR-Material.b2mml.

```
1   <MaterialInformation xmlns="http://www.mesa.org/xml/B2MML-V0600">
2       <MaterialClass>
3           <ID>Car-without-Wheels-Class</ID>
4           <Description>
5               Cars without Wheels of all kind belong to the Car-without-Wheels material
6               class.
7           </Description>
8           <MaterialDefinitionID>Car-without-Wheels</MaterialDefinitionID>
9       </MaterialClass>
10      <MaterialClass>
11          <ID>Wheel-Class</ID>
12          <Description>
13              Wheels of all kind belong to the Wheel material class.
14          </Description>
15          <MaterialDefinitionID>Wheel</MaterialDefinitionID>
16      </MaterialClass>
17      <MaterialClass>
18          <ID>Car-with-Wheels-Class</ID>
19          <Description>
20              Cars with Wheels of all kind belong to the Car-with-Wheels material class.
21          </Description>
22          <MaterialDefinitionID>Car-with-Wheels</MaterialDefinitionID>
23          <AssemblyClassID>Car-without-Wheels-Class</AssemblyClassID>
24          <AssemblyClassID>Wheel-Class</AssemblyClassID>
25          <AssemblyType>Physical</AssemblyType>
26          <AssemblyRelationship>Permanent</AssemblyRelationship>
27      </MaterialClass>
28      <MaterialDefinition>
29          <ID>Car-without-Wheels</ID>
30          <Description>A car that has no wheels attached.</Description>
31          <MaterialClassID>Car-without-Wheels-Class</MaterialClassID>
32      </MaterialDefinition>
33      <MaterialDefinition>
34          <ID>Wheel</ID>
35          <Description>A wheel that is to be attached to a car.</Description>
36          <MaterialClassID>Wheel-Class</MaterialClassID>
37      </MaterialDefinition>
38      <MaterialDefinition>
39          <ID>Car-with-Wheels</ID>
40          <Description>A car with wheels attached.</Description>
41          <MaterialClassID>Car-with-Wheels-Class</MaterialClassID>
42          <AssemblyDefinitionID>Car-without-Wheels</AssemblyDefinitionID>
43          <AssemblyDefinitionID>Wheel</AssemblyDefinitionID>
44          <AssemblyType>Physical</AssemblyType>
45          <AssemblyRelationship>Permanent</AssemblyRelationship>
46      </MaterialDefinition>
47  </MaterialInformation>
```

Listing 13 depicts the IEC 62264 process segment information encoded in B2MML. Process segments are the IEC 62264 equivalent of AML processes. In order to list several process segments in one document, the root element ProcessSegmentInformation is to be used. In this example five process segments are defined, corresponding to the processes of the PPR-setup. From the B2MML code given in Listing 13 a lot of information can be extracted that might be of use in the context of AutomationML. This information could be used to enrich the referencing AML document (and thus duplicate information, which might resemble a problem with regards to document maintenance), or it could be used by tools that understand AML and B2MML to infer knowledge for advanced tasks (such as simulation). The information provided in Listing 13 includes:

1. the process itself is assigned to an equipment level (e.g. Transport-1 takes place on the work cell level),

2. the duration of a process (e.g. Transport-1 takes 30 seconds: "PT30S"),

3. the equipment and material required for the process (this information should correspond to information encoded in AML using the PPR method),

4. a quantity for the involved equipment (e.g. 30 machine seconds per piece for Conveyer-1),

5. a quantity for the required material (e.g. 1 unit of cars without wheels for Transport-1),

6. the role of the involved material: is it consumed, produced, or moved (e.g. in the Assemble process segment, the materials Wheel and Car-without-Wheels are consumed, while the material Car-with-Wheels is produced)? This kind of information is not commonly defined in the PPR method,

7. segment dependencies define how two process segments are depending on each other (e.g. "Start Turn after Transport-1 end", which resembles a time constraint that the turn process must not start earlier than after Transport-1 has finished).

Listing 13: Contents of document PPR-ProcessSegments.b2mml.

```
1   <ProcessSegmentInformation xmlns="http://www.mesa.org/xml/B2MML-V0600">
2      <ProcessSegment>
3         <ID>Transport-1</ID>
4         <Description>
5            Transport 1 is accomplished with Conveyer 1. Cars without wheels are
6            delivered from the product source to the turntable.
7         </Description>
8         <OperationsType>Production</OperationsType>
9         <HierarchyScope>
10           <EquipmentElementLevel OtherValue="">WorkCell</EquipmentElementLevel>
11        </HierarchyScope>
12        <Duration>PT30S</Duration>
13        <EquipmentSegmentSpecification>
14           <EquipmentID>Conveyer-1</EquipmentID>
15           <Description>
16              Conveyer needed for transporting cars without wheels to the turntable.
17           </Description>
18           <EquipmentUse>Material Movement</EquipmentUse>
19           <Quantity>
20              <QuantityString>30</QuantityString>
21              <UnitOfMeasure>Machine Seconds / Piece</UnitOfMeasure>
22           </Quantity>
23        </EquipmentSegmentSpecification>
24        <MaterialSegmentSpecification>
25           <MaterialDefinitionID>Car-without-Wheels</MaterialDefinitionID>
26           <Description>
27              The cars without wheels that are to be transported.
28           </Description>
29           <MaterialUse>Material Moved</MaterialUse>
30           <Quantity>
31              <QuantityString>1</QuantityString>
32              <UnitOfMeasure>Units</UnitOfMeasure>
33           </Quantity>
34        </MaterialSegmentSpecification>
35     </ProcessSegment>
36     <ProcessSegment>
```

```
37          <ID>Transport-2</ID>
38          <Description>
39              Transport 2 is accomplished with Conveyer 2. Cars without wheels are
40              delivered from the turntable to the robot.
41          </Description>
42          <OperationsType>Production</OperationsType>
43          <HierarchyScope>
44              <EquipmentElementLevel OtherValue="">WorkCell</EquipmentElementLevel>
45          </HierarchyScope>
46          <Duration>PT10S</Duration>
47          <EquipmentSegmentSpecification>
48              <EquipmentID>Conveyer-2</EquipmentID>
49              <Description>
50                  Conveyer needed for transporting cars without wheels from the turntable
51                  to the robot.
52              </Description>
53              <EquipmentUse>Material Movement</EquipmentUse>
54              <Quantity>
55                  <QuantityString>10</QuantityString>
56                  <UnitOfMeasure>Machine Seconds / Piece</UnitOfMeasure>
57              </Quantity>
58          </EquipmentSegmentSpecification>
59          <MaterialSegmentSpecification>
60              <MaterialDefinitionID>Car-without-Wheels</MaterialDefinitionID>
61              <Description>
62                  The cars without wheels that are to be transported.
63              </Description>
64              <MaterialUse>Material Moved</MaterialUse>
65              <Quantity>
66                  <QuantityString>1</QuantityString>
67                  <UnitOfMeasure>Units</UnitOfMeasure>
68              </Quantity>
69          </MaterialSegmentSpecification>
70          <SegmentDependency>
71              <ID>Transport-2-after-Turn</ID>
72              <Description>Transport 2 after Turn</Description>
73              <Dependency>Start Transport 2 after Turn end</Dependency>
74              <ProcessSegmentID>Turn</ProcessSegmentID>
75          </SegmentDependency>
76      </ProcessSegment>
77      <ProcessSegment>
78          <ID>Transport-3</ID>
79          <Description>
80              Transport 3 is accomplished with Conveyer 2. Cars with wheels are delivered
81              from the robot to the product drain for finished products.
82          </Description>
83          <OperationsType>Production</OperationsType>
84          <HierarchyScope>
85              <EquipmentElementLevel OtherValue="">WorkCell</EquipmentElementLevel>
86          </HierarchyScope>
87          <Duration>PT10S</Duration>
88          <EquipmentSegmentSpecification>
89              <EquipmentID>Conveyer-2</EquipmentID>
90              <Description>
91                  Conveyer needed for transporting cars with wheels from the robot to the
92                  product drain.
93              </Description>
94              <EquipmentUse>Material Movement</EquipmentUse>
95              <Quantity>
96                  <QuantityString>10</QuantityString>
97                  <UnitOfMeasure>Machine Seconds / Piece</UnitOfMeasure>
98              </Quantity>
99          </EquipmentSegmentSpecification>
100         <MaterialSegmentSpecification>
101             <MaterialDefinitionID>Car-with-Wheels</MaterialDefinitionID>
102             <Description>The cars with wheels that are to be transported.</Description>
```

```
103        <MaterialUse>Material Moved</MaterialUse>
104        <Quantity>
105            <QuantityString>1</QuantityString>
106            <UnitOfMeasure>Units</UnitOfMeasure>
107        </Quantity>
108      </MaterialSegmentSpecification>
109      <SegmentDependency>
110        <ID>Transport-3-after-Assemble</ID>
111        <Description>Transport 3 after Assemble</Description>
112        <Dependency>Start Transport 3 after Assemble end</Dependency>
113        <ProcessSegmentID>Assemble</ProcessSegmentID>
114      </SegmentDependency>
115    </ProcessSegment>
116    <ProcessSegment>
117      <ID>Turn</ID>
118      <Description>
119        Turning is accomplished by the turntable that might hold a car without
120        wheels. Cars without wheels that should be assembled are turned
121        towards Conveyer 2, the ones that should not be further processed are
122        turned towards the product drain for unfinished products.
123      </Description>
124      <OperationsType>Production</OperationsType>
125      <HierarchyScope>
126        <EquipmentElementLevel OtherValue="">WorkCell</EquipmentElementLevel>
127      </HierarchyScope>
128      <Duration>PT15S</Duration>
129      <EquipmentSegmentSpecification>
130        <EquipmentID>Turntable</EquipmentID>
131        <Description>
132            Turntable needed for turning cars to either Conveyer 2 or to the product
133            drain for unfinished products.
134        </Description>
135        <EquipmentUse>Material Movement</EquipmentUse>
136        <Quantity>
137            <QuantityString>15</QuantityString>
138            <UnitOfMeasure>Machine Seconds / Piece</UnitOfMeasure>
139        </Quantity>
140      </EquipmentSegmentSpecification>
141      <MaterialSegmentSpecification>
142        <MaterialDefinitionID>Car-without-Wheels</MaterialDefinitionID>
143        <Description>The cars without wheels that are to be turned.</Description>
144        <MaterialUse>Material Moved</MaterialUse>
145        <Quantity>
146            <QuantityString>1</QuantityString>
147            <UnitOfMeasure>Units</UnitOfMeasure>
148        </Quantity>
149      </MaterialSegmentSpecification>
150      <SegmentDependency>
151        <ID>Turn-after-Transport-1</ID>
152        <Description>Turn after Transport 1</Description>
153        <Dependency>Start Turn after Transport 1 end</Dependency>
154        <ProcessSegmentID>Transport-1</ProcessSegmentID>
155      </SegmentDependency>
156    </ProcessSegment>
157    <ProcessSegment>
158      <ID>Assemble</ID>
159      <Description>
160        Assembling is accomplished by the robot, which attaches wheels to cars
161        without wheels in order to transform them into cars with wheels.
162      </Description>
163      <OperationsType>Production</OperationsType>
164      <HierarchyScope>
165        <EquipmentElementLevel OtherValue="">WorkCell</EquipmentElementLevel>
166      </HierarchyScope>
167      <Duration>PT2M</Duration>
168      <EquipmentSegmentSpecification>
```

```
169          <EquipmentID>Robot</EquipmentID>
170          <Description>
171             Robot needed for attaching wheels to cars without wheels.
172          </Description>
173          <EquipmentUse>Attach Wheels</EquipmentUse>
174          <Quantity>
175             <QuantityString>2</QuantityString>
176             <UnitOfMeasure>Machine Minutes / Piece</UnitOfMeasure>
177          </Quantity>
178       </EquipmentSegmentSpecification>
179       <MaterialSegmentSpecification>
180          <MaterialDefinitionID>Car-without-Wheels</MaterialDefinitionID>
181          <Description>The cars without wheels that are to be refined.</Description>
182          <MaterialUse>Material Consumed</MaterialUse>
183          <Quantity>
184             <QuantityString>1</QuantityString>
185             <UnitOfMeasure>Units</UnitOfMeasure>
186          </Quantity>
187       </MaterialSegmentSpecification>
188       <MaterialSegmentSpecification>
189          <MaterialDefinitionID>Wheel</MaterialDefinitionID>
190          <Description>The wheels that are to be attached.</Description>
191          <MaterialUse>Material Consumed</MaterialUse>
192          <Quantity>
193             <QuantityString>4</QuantityString>
194             <UnitOfMeasure>Units</UnitOfMeasure>
195          </Quantity>
196       </MaterialSegmentSpecification>
197       <MaterialSegmentSpecification>
198          <MaterialDefinitionID>Car-with-Wheels</MaterialDefinitionID>
199          <Description>The cars with wheels that are produced.</Description>
200          <MaterialUse>Material Produced</MaterialUse>
201          <Quantity>
202             <QuantityString>1</QuantityString>
203             <UnitOfMeasure>Units</UnitOfMeasure>
204          </Quantity>
205       </MaterialSegmentSpecification>
206       <SegmentDependency>
207          <ID>Assemble-after-Transport-2</ID>
208          <Description>Assemble after Transport 2</Description>
209          <Dependency>Start Assemble after Transport 2 end</Dependency>
210          <ProcessSegmentID>Transport-2</ProcessSegmentID>
211       </SegmentDependency>
212    </ProcessSegment>
213 </ProcessSegmentInformation>
```