SISO-STD-008-01-2012

Standard for
Core Manufacturing
Simulation Data
— XML Representation

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1 Introduction

This product, Core Manufacturing Simulation Data (CMSD), addresses interoperability between simulation systems and other manufacturing applications. The CMSD information model is a standard representation for core manufacturing simulation data. It provides neutral structures for the efficient exchange of manufacturing data in a simulation environment. These neutral structures can be used to support the integration of simulation software with other manufacturing applications.

The specification of the CMSD information model is presented using two different methods: 1) the information model defined using the Unified Modeling Language (UML); and 2) the information model defined using a schema language for XML representation. The information model defined using UML is published as the SISO Standard, SISO-STD-008-2010 (1). The information model defined using XML is presented in this document.

1.1 Purpose

The purpose of this product is to:

- enable data exchange between simulation applications and other software applications;
- support the construction of manufacturing simulators;
- support the testing and evaluation of manufacturing software; and
- enable greater manufacturing software application interoperability.

1.2 Scope

The CMSD information model describes the essential entities in the manufacturing domain and the relationships between those entities needed to create manufacturing-oriented simulations. This model facilitates the exchange of information between manufacturing-oriented simulations and other applications in manufacturing domains such as process planning, scheduling, inventory management, production management, and plant layout. The model is not intended to be an all-inclusive definition of either the entire manufacturing domain or simulation domain.

1.3 Objective

The primary objective of this standard is to provide a data specification that enables the efficient exchange of manufacturing life-cycle data in a simulation environment. The objective is intended to:

- foster the development and use of simulations in manufacturing operations;
- facilitate data exchange between simulation and other manufacturing software applications;
- enable and facilitate better testing and evaluation of manufacturing software; and
- increase manufacturing application interoperability.

1.4 Intended Audience

The primary audience for this document is the manufacturing-oriented modeling and simulation community. Other communities of interest, although not the intended primary audience, are encouraged to leverage the standard described here for use in their domains.

1.5 Acknowledgements

This document was created as a community effort by the Core Manufacturing Simulation Data (CMSD) Product Development Group (PDG). This PDG was chartered by the Simulation Interoperability Standards Organization (SISO) Standards Activity Committee (SAC) in September 2004 (2). This document would not have been possible without the hard work and dedicated efforts of the following individuals:

At the time this product was submitted to the Standards Activity Committee for approval, the CMSD PDG had the following membership:

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Y. Tina Lee (Secretary)
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Scrudder, Roy
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Whittington, Eric

2 References

2.1 SISO References

	Document Number	Title
1.	SISO-STD-008-2010	Standard for Core Manufacturing Simulation Data – UML Model
2.	SISO-PN-002-2011	Product Nomination for Standard Representation for Core Manufacturing Simulation Data
3.	SISO-ADM-002-2011	SISO Policies & Procedures
4.	SISO-ADM-003-2011	SISO Balloted Products Development and Support Process
5.	SISO-ADM-005-2011	Policy for: The Style and Format of SISO Documents

SISO Administrative Products (3-5) were used when preparing this SISO Standard.

2.2 Other References

The following normative references contain material that must be understood and used to implement the SISO Standard.

	Document Number	Title
6.	ISO/IEC 19757-2:2008	Information technology -- Document Schema Definition Language (DSDL) -- Part 2: Regular-grammar-based validation -- RELAX NG
7.	ISO/IEC 19757-3:2006	Information technology -- Document Schema Definition Languages (DSDL) -- Part 3: Rule-based validation -- Schematron
8.	World Wide Web Consortium (W3C) XML Path Language (XPath) Version 1.0	XML Path Language (XPath)
9.	World Wide Web Consortium (W3C) XML Schema Part 2: Datatypes Second Edition	XML Schema Datatypes

3 Definitions

Term	Definition
Bill of materials	A description of the hierarchical relationships between a part and its subcomponents.
Calendar	A long term focused collection of shift and holiday information that, taken together, specify the time periods during which production is and is not expected to take place.
CMSD document	An aggregation of information that is organized based on the CMSD specification and that is suitable for exchange or archival.
Cost	The expense incurred by an enterprise due to its performing some manufacturing activity.
Distribution	The name and parameter values that define a statistical distribution. A statistical distribution is a mathematical function where: 1) the range of possible values of the function is known, and; 2) the probability that a random input to the domain of the function will produce an output value in a subset of the range is also known.
Entity	An abstraction used in the CMSD information model to represent a common manufacturing or business concept.
Event	The documentation of the planned or actual occurrence of some phenomenon or the reaching of some milestone.
Identifier	An attribute of an entity that is used to differentiate that entity from other entities of the same kind.
Inventory item	A part or (non-employee) resource for which information about its availability for production activities is tracked.
Inventory item type	Information about a kind of part or kind of (non-employee) resource that can be an inventory item.
Job	A request for production-related activities to take place, originating from a person or organization internal to the manufacturing enterprise.
Layout	A representation of the spatially-relevant characteristics of, and relationships between, the manufacturing resources that are a part of a manufacturing facility.
Limited unique entity	An entity whose instances are unique but only within the scope of its parent entity.
Lot	Information about a group of parts that were manufactured together or obtained together, and that have some important characteristic.
Machine program	A set of instructions that allow a computer-controlled machine tool to perform a specific manufacturing function.
Maintenance plan	A collection of maintenance processes that provide the necessary instructions for maintaining a (non-employee) manufacturing resource.
Maintenance process	A manufacturing activity or group of manufacturing activities that perform a corrective or preventive maintenance operation on a resource.
Metadata	Information about the format and value space that is allowable for a given property attribute.
Order	A request for products or services originating from a person or organization external to the manufacturing enterprise.

Term	Definition
Parent entity	An entity that has other entities nested within it. A parent entity defines a scope for determining the uniqueness of multiple instances of the same kind of entity that may be nested within it.
Part	A raw material or sub-component used in or produced by some stage of production, or an end product that is the final objective of production.
Part type	Information about the characteristics of a specific kind of part.
Process	A manufacturing activity or group of manufacturing activities that either: 1) transforms a part from a known state/condition to another known state/condition; 2) transports a part from a known location to another location; 3) verifies that a part is in a known state state/condition or location, or; 4) all of the above.
Process Plan	A collection of processes that provide the necessary instructions for producing a part.
Property	A means for extending the information that can be associated with an entity by allowing name and value information for a noteworthy characteristic of the entity to be associated with that entity.
Property attribute	A characteristic of an entity that was specified using property information.
Resource	A piece of equipment or an employee that is performing or is to perform a manufacturing activity.
Resource class	Information about the characteristics of a specific kind of resource.
Schedule	A plan containing a time-ordered collection of production activities, and/or the results obtained by carrying out such a plan.
Shift	A time period during a day of the week when production activities are to take place and a specification of the days on which this time period is applicable.
Shift schedule	An intermediate term collection of shift and holiday information specifying when production is and is not expected to take place.
Unique entity	An entity whose instances are unique within the scope of a CMSD document.

4 Acronyms and Abbreviations

ADM	Administrative procedures
ANSI	American National Standards Institute
BPDSP	Balloted Products Development and Support Process
CC	Conference Committee
CMSD	Core Manufacturing Simulation Data
CSS2	Cascading Styling Sheet, Level 2
DG	Drafting Group
DSDL	Document Schema Definition Languages
EXCOM	Executive Committee
FF	Finish-To-Finish precedence relationship
FS	Finish-To-Start precedence relationship
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISO	International Organization for Standardization
M&S	Modeling and Simulation
NIST	National Institute of Standards and Technology
OASIS	Organization for the Advancement of Structured Information Standards
OMG	Object Management Group
PDG	Product Development Group
PN	Product Nomination
RELAX NG	Regular Language for XML Next Generation
RFC	Request for Comments
RGB	Red, Green, Blue light intensity values that define a specific color
SAC	Standards Activity Committee
SF	Start-To-Finish precedence relationship
SI	International System of Units
SISO	Simulation Interoperability Standards Organization
SS	Start-To-Start precedence relationship
STD	Standard
TAD	Technical Area Director
UML	Unified Modeling Language
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
URN	Uniform Resource Name
W3C	World Wide Web Consortium
XML	eXtensible Markup Language

5 Overview

The CMSD UML model, SISO-STD-008-2010 (1), is designed as a suite of interrelated collections of information modeled as UML classes contained within UML packages, presented visually as a series of UML class and package diagrams. The objective of the CMSD - XML representation is to define the structure and content for XML documents that adhere to the rules and constraints defined in the CMSD UML model.

5.1 XML and the Schema Languages that define the XML Representation of CMSD

XML is a set of rules for encoding documents in machine-readable format. XML provides a foundation for supporting document development, data exchange, and integration.

To define the specific structure and content an XML document may contain, a set of rules governing the acceptable structure and content can be constructed. This set of rules is referred to as a schema.

To define the rules governing the content and structure for a CMSD document represented in XML, two different languages for defining schemas were used. This approach was taken because no existing schema language for XML could support all of the complex interrelationships between the entities defined by the CMSD UML model. The languages used are the Regular Language for XML Next Generation (RELAX NG) and Schematron. Appendix B contains information about the CMSDTools Sourceforge project established during development of this standard to disseminate information.

This document assumes that the reader has a working knowledge of XML. Additional information about XML can be found in the XML related standards listed in section 2 of this document (8-9).

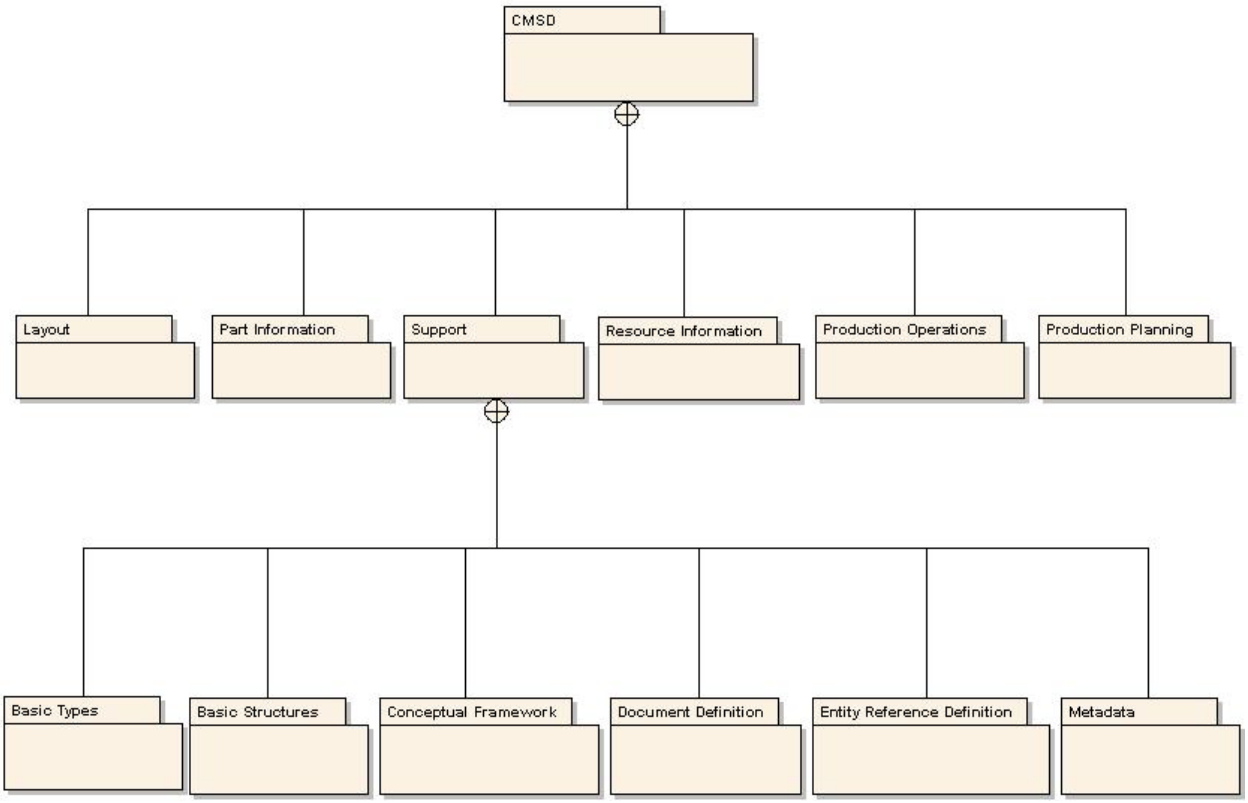


Figure 1 - CMSD UML Packages

5.2 CMSD UML to XML Realization Strategy

5.2.1 UML Package to Schema File Associations

Figure 1 presents a package diagram that shows all of the packages defined for the CMSD UML model. Table 1 shows the relationship between the packages defined by the CMSD UML model and the files which contain the schema elements of the XML representation for CMSD. Files ending with ".rng" contain RELAX NG grammars and files ending in ".sch" contain Schematron schemas. In general, the grammar within each RELAX NG file specifies the XML content and structural representation for the UML class and association definitions contained within the associated UML package. The "CMSD.sch" file contains a Schematron schema defining rules that apply to CMSD classes that may have been defined in any CMSD UML package.

Table 1 - Package to Schema File Associations

CMSD UML Package Name	RELAX NG/Schematron Schema File Name
CMSD Package[1]	CMSD.rng[2]
Layout Package	Layout.rng
Part Information Package	Part.rng
Resource Information Package	Resource.rng
Production Operations Package	ProductionOperations.rng
Production Planning Package	ProductionPlanning.rng
Support Package[3]	
Basic Types Package	BasicTypes.rng
Basic Structures Package	BasicStructures.rng
Conceptual Framework Package	ConceptualFramework.rng
Document Definition Package	DocumentDefinition.rng
Entity Reference Definition Package	EntityReferenceDefinition.rng
Metadata Package	Metadata.rng
	CMSD.sch[4]

[1]: The CMSD package contains all of the other packages in the CMSD UML model.

[2:] The CMSD Relax NG grammar merges all of the other grammas in one cohesive grammar.

[3]: No Relax NG grammar or Schematron schema is directly associated with this package

[4]: The rules defined in the Schematron schema may apply to CMSD entities defined in any of the CMSD UML packages, and as such, the Schematron schema does not have an individual CMSD UML package association.

5.2.2 CMSD UML Class/Attribute to XML Element/Sub-Element Mapping

In the CMSD UML Model, the manufacturing concepts within each package are modeled as UML classes and the characteristics that define the different aspects of those concepts are modeled as UML class attributes. A CMSD class may also define its attributes through UML aggregation relationships with other CMSD classes.

In general, each class in the CMSD UML model is realized in XML as an XML element of the same name. The UML attributes defined for that class are realized as XML elements nested within the element associated with the class.

5.2.3 Data types for CMSD attributes are based on XML Schema Part 2: Datatypes

Classes that define basic data types in CMSD, such as the CMSD String class or the CMSD Date class, are defined based on the data types specified in the W3C XML Schema Datatypes (9) recommendation. All class attributes in CMSD are defined using either the CMSD basic types or other CMSD classes (that were defined based on the CMSD basic types). This enables all CMSD classes to be realized as XML elements that contain XML compatible data (as specified by the W3C XML Schema Datatypes recommendation).

5.2.4 The CMSDDocument class defines the root for a CMSD document in XML

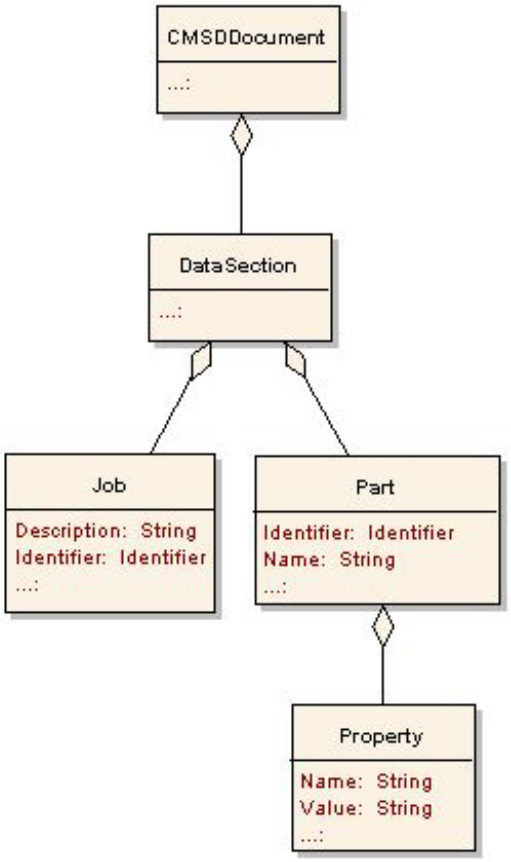
Conceptually, a “CMSD document” is a collection of CMSD entities (defined by CMSD classes) and related information, assembled in a way such that the assemblage is appropriate for archiving or exchange. It also defines the scope for determining the uniqueness of the entities it contains. In the CMSD UML model, the CMSDDocument class implements this concept, and all other CMSD classes are either directly or indirectly aggregated within it.

The CMSDDocument class is realized in XML as an XML element named “CMSDDocument”. The CMSDDocument element is the root element for the XML representation of the conceptual “CMSD document”. Within the CMSDDocument element are other XML elements: 1) defined according to the CMSD UML class to XML element strategy (as described section 5.2.2 and section 5.2.3), and; 2) nested according to the class’ aggregation relationship with the CMSDDocument class and the other CMSD UML classes. This approach allows any CMSD UML class to be realized in XML and nested appropriately within a CMSDDocument root element.

5.3 CMSDDocument Example

In Table 2, an example is presented that shows how a CMSD document is defined in UML and how that information should be realized in XML. On the left side of the table, simplified versions of several classes that make up the CMSD UML model are presented in a UML class diagram. Some of the attributes for and the aggregation relationships between those classes are presented. Ellipses are used to indicate where class attributes defined in the CMSD UML model have been left out of the example diagram. The right side of the table shows how the same CMSD document information would be represented in XML.

Table 2 - CMSD Document example - UML and XML representations

CMSD document example in UML	CMSD document example in XML
	<CMSDDocument> <DataSection> <Job> <Identifier>111_abc</Identifier> <Description> A job to make the part widget1 </Description> ... </Job> <Part> <Identifier>widget1_abc123</Identifier> <Name>Widget1 Computer part</Name> <Property> <Name>ModelName</Name> <Value>Widget1_abc123</Value> ... </Property> ... </Part> ... </DataSection> ... </CMSDDocument>

5.4 CMSD XML Representation Schema Languages

5.4.1 RELAX NG Schema – Definition and Terms

The Regular Language for XML Next Generation (RELAX NG) (6) is the primary schema language for defining the XML representation of CMSD. RELAX NG is a grammar-based XML schema language developed by the Organization for the Advancement of Structured Information Standards (OASIS). It is Part 2 of ISO/IEC 19757: Document Schema Definition Languages (DSDL) (7). A RELAX NG schema specifies a grammar that defines: 1) the acceptable names and content for tagged XML data; and 2) patterns governing where the tags may appear in XML documents that comply with the grammar.

In Table 3, several concepts related to how RELAX NG can be used to describe the valid form for XML documents are described. Table 4 provides brief descriptions of the key RELAX NG elements that are used in CMSD. The information provides a brief introduction to how RELAX NG was used to define the CMSD XML representation, but it is not intended to be a complete, in depth, description of RELAX NG.

Table 3 - RELAX NG Concepts

RELAX NG Concepts	Description
Pattern	RELAX NG defines information that specifies “patterns” for the name, position, and content type for the elements and attributes that make up an XML document. Patterns may be given a name which allows them to be referred to by other patterns, or they may be defined inline as sub-patterns of another pattern. A pattern may define: • The name of and data type for the content of an XML element or attribute • A custom format that can be used as the data type for the content of an XML element or attribute • A list of string literals that can be used as the data type for the content of an XML element or attribute • Ordering and multiplicity constraints for a group of XML elements or attributes
Datatype	While the character data in an XML document (all characters that are not tags or other markup symbols) could be considered to be of type string, it is often advantageous to provide a more precise definition of character data content. RELAX NG allows the use of any of the simple data types defined in the W3C XML Schema Datatypes recommendation. RELAX NG also provides a mechanism for defining a custom library of data type definitions, but the CMSD representation for XML does not make use of this capability.
Grammar	A RELAX NG grammar is a collection of RELAX NG pattern definitions that can be used to define the content of an XML document. A grammar may also define the name and content for the root element for an XML document. Grammars may be nested within other grammars, either through direct inline definition or by reference to grammars defined externally. In general in CMSD, grammars are defined for each UML package defined in the CMSD UML model, and those grammars are stored in files named similarly to the packages. The patterns that are contained within a grammar define the XML representations for UML classes defined within their associated packages.
Namespace	RELAX NG supports XML Namespaces, both in defining the namespace for RELAX NG markup and in defining how namespaces should be used on tags in the XML instance documents described by a RELAX NG grammar.
Reference	A RELAX NG element indicating the content that may appear at the current location of a pattern is defined by the named pattern whose definition is elsewhere in the grammar.
Aggregation vs Inheritance	In the CMSD UML model, inheritance is used to define the attributes of a class, referred to as the subclass, in terms of the attributes defined for another class, referred to as the superclass. When inheritance is used in UML, any attributes defined for the superclass are considered to also be defined for the subclass. RELAX NG does not support inheritance, but the same effect can be achieved through aggregation. If a named pattern is defined to describe the attributes defined for the superclass, the pattern that defines the attributes of subclass can “reference” the pattern for the superclass. In this way, the pattern for subclass will contain all information defined for the superclass in addition to any new information defined only in the subclass.

Table 4 - Key RELAX NG Elements

Element Name	Description
<grammar>	This element defines a collection of patterns that specify the format and content for information in an XML document. In CMSD, this element typically contains attributes specifying: 1) how namespaces related to RELAX NG are handled, and; 2) what the default library data types should be. The grammar element may contain a start element defining the root element for an XML document based on the grammar, and it may also include elements indicating that grammars defined in other files should be merged into this grammar.
<include>	This element indicates that the grammar defined in the named file should be merged with content and format definitions in the enclosing grammar.
<define>	This element defines a named pattern for XML content. The content may be defined in terms of data type specifications, literal string values, XML element definitions, or references to other named patterns.
<data>	In CMSD, this element indicates that the content of the pattern should adhere to the referenced named data type defined in the W3C XML Schema Datatypes recommendation.
<value>	This element indicates that the content of the pattern should match the provided string literal value.
<choice>	This element defines a pattern as one of the nested sub-patterns defined within it. Sub-patterns are typically defined in terms of value, element, or reference elements that may, in turn, be enclosed in one of the multiplicity indicating elements.
<element>	This element indicates that an XML element of the specified name is to be a part of the enclosing pattern.
<attribute>	This element indicates that an XML attribute of the specified name is to be a part of the enclosing pattern. The <attribute> element is rarely used in the XML representation for CMSD.
<start>	This element defines the name and content of the root element of an XML document.
<ref>	The element indicates that the content and format of the named pattern is also the content and format for information at this point in the enclosing pattern.
<optional>, <zeroOrMore>,or <oneOrMore>	These elements define the multiplicity of the sub-patterns they enclose. They indicate that zero or one, zero or more, or one or more copies of the enclosed sub-pattern may appear at this point in a pattern.
<interleave>	This element indicates that in an instance document, the XML elements defined in or referenced by this pattern may appear in any order.
<documentation>	This element provides a means to include descriptive text or comments about the grammar in the elements that make up a grammar definition. The <documentation> element's content does not affect the meaning of the RELAX NG elements within which it appears, and does not appear in instance documents based on the associated grammar.

5.4.2 Schematron Schema – Definition and Terms

Schematron is a rule-based XML schema language. It is Part 3 of ISO/IEC 19757: DSDL. Schematron (9) allows making assertions about the presence or absence of patterns in XML trees. Schematron was designed to allow multiple, well-focused XML validation languages to work together. This ability allows Schematron to be used in concert with Relax NG to define the content or structural constraints specified in the CMSD UML model in a way that could not be accomplished by using Relax NG alone.

In Table 5, several concepts related to how Schematron can be used to describe the valid format and content for XML information are described. Table 6 provides brief descriptions of the key Schematron elements that are used in CMSD. The information provides a brief introduction to how Schematron was used to define the valid content for the CMSD XML representation, but it is not intended to be a complete, in depth, description of the Schematron language.

Table 5 - Schematron Concepts

Schematron Concepts	Description
Rule	A Schematron rule indicates that for the specified collection of XML nodes in a document, those nodes must meet specified content and format criteria. The set of nodes, called a node-set, is specified using an XPath string and denotes the “context” to which the rule applies. Within a rule, one or more “assertions” about the allowable format and content for the nodes in the rule’s node-set can be specified. Each assertion has an XPath string that defines specific criteria to which all valid nodes in a context must adhere. A user-friendly description of the meaning of the assertion can also be specified. When Schematron is used to check the information in an XML document, the criteria specified in the assertions are checked against the nodes specified by the context of the rule associated with the assertion, and information about any nodes that do not adhere to the specified criteria are reported back to the user.
Pattern	A pattern is a collection of Schematron rules, which might be related in some way. Information about how the rules are related may also be specified.
Context	The set of XML nodes to which the assertions in a Schematron rule apply.
Assertion	A statement that defines validity criteria to which each XML node (in the context defined for the rule associated with the assertion) must adhere.
XPath	The W3C standard that specifies a language for identifying specific XML nodes in an XML document. It defines functions for identifying nodes and sets of nodes based on their location in an XML document and on their content.
Schema	A Schematron schema is a collection of patterns containing a collection of rules that define assertions specifying the valid format and content for information in an XML document.

Table 6 - Key Schematron elements

Schematron Element Name	Description
<schema>	This element is the root element for a Schematron schema. It contains all of the <pattern> elements containing the rules and assertions that are used to define the format and content of an XML document.
<pattern>	This element represents a pattern in a Schematron schema. It has a “Name” attribute that allows the specification of a description of the pattern.
<rule>	This element represents a Schematron rule. It has a “context” attribute that contains an XPath string that defines the set of nodes in an XML document to which the rule applies. Nested within the <rule> element are one or more <assert> elements.
<assert>	This element defines a Schematron assertion. It has a “test” attribute that contains an XPath string that defines testable criteria against which the XML nodes in the context of the associated Schematron rule can be tested. The content of the <assert> element may contain a text description of the content and format criteria that is being asserted.

6 The Core Manufacturing Simulation Data RELAX NG Grammars

In this section, definitions for the RELAX NG grammars that define the format and content for the CMSD XML representation are presented. Each grammar is presented in a separate section. The main CMSD RELAX NG grammar is presented first, followed by the other grammars in the order in which they are included into the main grammar.

6.1 CMSD grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">
      <rng:start>
            <rng:element name="CMSDDocument">
                  <rng:ref name="CMSDDocument"/>
            </rng:element>
      </rng:start>
      <rng:include href="BasicTypes.rng"/>
      <rng:include href="BasicStructures.rng"/>
      <rng:include href="EntityReferenceDefinition.rng"/>
      <rng:include href="ConceptualFramework.rng"/>
      <rng:include href="Metadata.rng"/>
      <rng:include href="DocumentDefinition.rng"/>
      <rng:include href="Part.rng"/>
      <rng:include href="Resource.rng"/>
      <rng:include href="ProductionPlanning.rng"/>
      <rng:include href="ProductionOperations.rng"/>
      <rng:include href="Layout.rng"/>
</rng:grammar>
```

6.2 Basic Types Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">
      <!-- ***************************************************************************

            Extended Primitive Types

         ***************************************************************************
         -->
      <rng:define name="Identifier">
            <rng:data datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes"
                  type="string">
                        <a:documentation>
                              Identifer may contain one or more occurrances
                              of any valid XML character except for the linefeed (hex 0A)
                              or carriage return (hex 0D) characters
                        </a:documentation>
                  <rng:param name="pattern">\S+</rng:param>
            </rng:data>
      </rng:define>

      <rng:define name="URI"
            datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">
            <rng:data type="anyURI"/>
      </rng:define>

      <rng:define name="Timestamp">
            <rng:data type="dateTime"/>
      </rng:define>

      <rng:define name="Time">
            <rng:data type="time"/>
      </rng:define>

      <rng:define name="Date">
            <rng:data type="date"/>
      </rng:define>

      <rng:define name="Integer">
            <rng:data type="integer"/>
      </rng:define>

      <rng:define name="Decimal">
            <rng:data type="decimal"/>
      </rng:define>

      <rng:define name="NonNegativeInteger">
            <rng:data type="nonNegativeInteger"/>
      </rng:define>

      <rng:define name="String">
            <rng:data type="string"/>
      </rng:define>
```

```
<rng:define name="Boolean">
	<rng:choice>
		<rng:value>true</rng:value>
		<rng:value>false</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="UnlimitedCardinality">
	<rng:choice>
		<rng:value>*</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="CardinalitySpecification">
	<rng:choice>
		<rng:ref name="NonNegativeInteger"/>
		<rng:ref name="UnlimitedCardinality"/>
	</rng:choice>
</rng:define>
<!-- ********************************************************************************

	Units of Measure related types

	********************************************************************************
	-->
<rng:define name="TimeUnit">
	<rng:choice>
		<rng:value>second</rng:value>
		<rng:value>minute</rng:value>
		<rng:value>hour</rng:value>
		<rng:value>day</rng:value>
		<rng:value>month</rng:value>
		<rng:value>week</rng:value>
		<rng:value>year</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="LengthUnit">
	<rng:choice>
		<rng:value>millimeter</rng:value>
		<rng:value>centimeter</rng:value>
		<rng:value>meter</rng:value>
		<rng:value>kilometer</rng:value>
		<rng:value>inch</rng:value>
		<rng:value>foot</rng:value>
		<rng:value>yard</rng:value>
		<rng:value>mile</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="WeightUnit">
	<rng:choice>
		<rng:value>ounce</rng:value>
		<rng:value>pound</rng:value>
		<rng:value>milligram</rng:value>
		<rng:value>ton</rng:value>
```

```
            <rng:value>centigram</rng:value>
            <rng:value>gram</rng:value>
            <rng:value>kilogram</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="AreaUnit">
        <rng:choice>
            <rng:value>squareInch</rng:value>
            <rng:value>squareFoot</rng:value>
            <rng:value>squareYard</rng:value>
            <rng:value>squareCentimeter</rng:value>
            <rng:value>squareMeter</rng:value>
            <rng:value>squareKilometer</rng:value>
            <rng:value>squareMile</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="VolumeUnit">
        <rng:choice>
            <rng:value>cubicCentimeter</rng:value>
            <rng:value>cubicInch</rng:value>
            <rng:value>cubicFoot</rng:value>
            <rng:value>cubicMeter</rng:value>
            <rng:value>cubicYard</rng:value>
            <rng:value>milliliter</rng:value>
            <rng:value>gallon</rng:value>
            <rng:value>liter</rng:value>
            <rng:value>pint</rng:value>
            <rng:value>quart</rng:value>
            <rng:value>ounce</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="PowerUnit">
        <rng:choice>
            <rng:value>horsepower</rng:value>
            <rng:value>watt</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="SpeedUnit">
        <rng:choice>
            <rng:value>footPerSecond</rng:value>
            <rng:value>kilometerPerHour</rng:value>
            <rng:value>meterPerSecond</rng:value>
            <rng:value>milePerHour</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="TemperatureUnit">
        <rng:choice>
            <rng:value>Celsius</rng:value>
            <rng:value>Fahrenheit</rng:value>
            <rng:value>kelvin</rng:value>
        </rng:choice>
```

```
</rng:define>

<rng:define name="CurrencyUnit">
	<rng:data datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes"
		type="string">
		<a:documentation>
			Currency codes should be 3 digit capital letters
			that adhere to ISO 4217
		</a:documentation>
		<rng:param name="pattern">[A-Z]{3}</rng:param>
	</rng:data>
</rng:define>
<!-- ********************************************************************************

	Metadata related types

	********************************************************************************
	-->
<rng:define name="PropertyType">
	<rng:choice>
		<rng:value>simple</rng:value>
		<rng:value>reference</rng:value>
		<rng:value>stochastic</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="ReferenceTypeName">
	<rng:choice>
		<rng:value>BillOfMaterialsReference</rng:value>
		<rng:value>BillOfMaterialsComponentReference</rng:value>
		<rng:value>CalendarReference</rng:value>
		<rng:value>DistributionDefinitionReference</rng:value>
		<rng:value>InventoryItemClassReference</rng:value>
		<rng:value>InventoryItemReference</rng:value>
		<rng:value>JobReference</rng:value>
		<rng:value>LayoutElementReference</rng:value>
		<rng:value>MaintenancePlanReference</rng:value>
		<rng:value>MaintenanceProcessReference</rng:value>
		<rng:value>OrderInformationReference</rng:value>
		<rng:value>PartReference</rng:value>
		<rng:value>PartTypeReference</rng:value>
		<rng:value>ProcessPlanReference</rng:value>
		<rng:value>ProcessReference</rng:value>
		<rng:value>ReferenceMaterialReference</rng:value>
		<rng:value>ResourceClassReference</rng:value>
		<rng:value>ResourceReference</rng:value>
		<rng:value>ScheduleInformationReference</rng:value>
		<rng:value>SetupChangeoverReference</rng:value>
		<rng:value>SetupDefinitionReference</rng:value>
		<rng:value>SkillReference</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="SimpleDataTypeName">
	<rng:choice>
		<rng:value>Time</rng:value>
```

```
            <rng:value>Date</rng:value>
            <rng:value>Timestamp</rng:value>
            <rng:value>String</rng:value>
            <rng:value>Identifier</rng:value>
            <rng:value>URI</rng:value>
            <rng:value>Decimal</rng:value>
            <rng:value>Boolean</rng:value>
            <rng:value>Integer</rng:value>
            <rng:value>NonNegativeInteger</rng:value>
            <rng:value>AreaUnit</rng:value>
            <rng:value>CurrencyUnit</rng:value>
            <rng:value>LengthUnit</rng:value>
            <rng:value>PowerUnit</rng:value>
            <rng:value>SpeedUnit</rng:value>
            <rng:value>TemperatureUnit</rng:value>
            <rng:value>WeightUnit</rng:value>
            <rng:value>TimeUnit</rng:value>
            <rng:value>VolumeUnit</rng:value>
        </rng:choice>
    </rng:define>

    <rng:define name="UnitTypeName">
        <rng:choice>
            <rng:value>AreaUnit</rng:value>
            <rng:value>CurrencyUnit</rng:value>
            <rng:value>LengthUnit</rng:value>
            <rng:value>PowerUnit</rng:value>
            <rng:value>SpeedUnit</rng:value>
            <rng:value>TemperatureUnit</rng:value>
            <rng:value>WeightUnit</rng:value>
            <rng:value>TimeUnit</rng:value>
            <rng:value>VolumeUnit</rng:value>
        </rng:choice>
    </rng:define>

    <rng:define name="PropertyExtensibleEntity">
        <rng:choice>
            <rng:value>Layout</rng:value>
            <rng:value>LayoutElement</rng:value>
            <rng:value>GraphicDescription</rng:value>
            <rng:value>BillOfMaterials</rng:value>
            <rng:value>LimitedUniqueEntity</rng:value>
            <rng:value>IdentifiableEntity</rng:value>
            <rng:value>UniqueEntity</rng:value>
            <rng:value>ColorHighlight</rng:value>
            <rng:value>ShapeLabelDefiniton</rng:value>
            <rng:value>Event</rng:value>
            <rng:value>ReferenceMaterial</rng:value>
            <rng:value>CostAllocationData</rng:value>
            <rng:value>DistributionDefinition</rng:value>
            <rng:value>SetupChangeoverDefinition</rng:value>
            <rng:value>SetupDefinition</rng:value>
            <rng:value>SkillDefinition</rng:value>
            <rng:value>SkillLevel</rng:value>
            <rng:value>Connection</rng:value>
            <rng:value>ResourceClass</rng:value>
```

```
            <rng:value>MaintenancePlan</rng:value>
            <rng:value>Resource</rng:value>
            <rng:value>MaintenanceProcess</rng:value>
            <rng:value>Process</rng:value>
            <rng:value>Holiday</rng:value>
            <rng:value>ProcessPlan</rng:value>
            <rng:value>Shift</rng:value>
            <rng:value>ShiftSchedule</rng:value>
            <rng:value>Calendar</rng:value>
            <rng:value>ScheduleItemEffortDescripton</rng:value>
            <rng:value>Schedule</rng:value>
            <rng:value>ScheduleItem</rng:value>
            <rng:value>Job</rng:value>
            <rng:value>JobEffortDescription</rng:value>
            <rng:value>Order</rng:value>
            <rng:value>OrderLine</rng:value>
            <rng:value>InventoryItem</rng:value>
            <rng:value>InventoryItemClass</rng:value>
            <rng:value>CurvedSegment</rng:value>
            <rng:value>PartType</rng:value>
            <rng:value>ImageGraphic</rng:value>
            <rng:value>Part</rng:value>
            <rng:value>SegmentShape</rng:value>
            <rng:value>StraightSegment</rng:value>
            <rng:value>ModelGraphic</rng:value>
            <rng:value>TextualAnnotation</rng:value>
            <rng:value>LayoutObject</rng:value>
        </rng:choice>
    </rng:define>
    <!-- ********************************************************************************

        Layout related types

        ********************************************************************************
        -->
    <rng:define name="PixelLengthUnit">
        <a:documentation>
            PixelLengthUnit is used in LayoutLengthUnit to extend LengthUnit
        </a:documentation>
        <rng:choice>
            <rng:value>pixel</rng:value>
        </rng:choice>
    </rng:define>

    <rng:define name="LayoutLengthUnit">
        <rng:choice>
            <rng:ref name="LengthUnit"/>
            <rng:ref name="PixelLengthUnit"/>
        </rng:choice>
    </rng:define>

    <rng:define name="TextAnchorLocation">
        <rng:choice>
            <rng:value>center</rng:value>
            <rng:value>upperLeft</rng:value>
        </rng:choice>
```

```
</rng:define>

<rng:define name="BasicShapeType">
	<rng:choice>
		<rng:value>box</rng:value>
		<rng:value>circle</rng:value>
		<rng:value>polygon</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="CoordinateSystem">
	<rng:choice>
		<rng:value>centerBased</rng:value>
		<rng:value>upperLeftBased</rng:value>
	</rng:choice>
</rng:define>
<rng:define name="BaseLocation">
	<rng:choice>
		<rng:value>floor</rng:value>
		<rng:value>ceiling</rng:value>
	</rng:choice>
</rng:define>
<rng:define name="ShapeDescriptionType">
	<rng:choice>
		<rng:value>basic</rng:value>
		<rng:value>graphic</rng:value>
		<rng:value>segment</rng:value>
		<rng:value>text</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="GraphicDescriptionType">
	<rng:choice>
		<rng:value>modelGraphic</rng:value>
		<rng:value>imageGraphic</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="ColorHexString">
	<rng:data type="string">
		<rng:param name="pattern">#[a-fA-F0-9]{6}</rng:param>
	</rng:data>
</rng:define>

<rng:define name="ColorName">
	<rng:choice>
		<rng:value>aqua</rng:value>
		<rng:value>black</rng:value>
		<rng:value>blue</rng:value>
		<rng:value>fuchsia</rng:value>
		<rng:value>gray</rng:value>
		<rng:value>green</rng:value>
		<rng:value>lime</rng:value>
		<rng:value>maroon</rng:value>
		<rng:value>navy</rng:value>
		<rng:value>olive</rng:value>
```

```
            <rng:value>purple</rng:value>
            <rng:value>red</rng:value>
            <rng:value>sliver</rng:value>
            <rng:value>teal</rng:value>
            <rng:value>white</rng:value>
            <rng:value>yellow</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="ColorDefinition">
        <rng:choice>
            <rng:ref name="ColorName"/>
            <rng:ref name="ColorHexString"/>
        </rng:choice>
</rng:define>

<rng:define name="SegmentType">
        <rng:choice>
            <rng:value>straight</rng:value>
            <rng:value>curved</rng:value>
        </rng:choice>
</rng:define>
<!-- ********************************************************************************

        Other Basic types

        ********************************************************************************
        -->
<rng:define name="ResourceType">
        <rng:choice>
            <rng:value>carrier</rng:value>
            <rng:value>conveyor</rng:value>
            <rng:value>crane</rng:value>
            <rng:value>employee</rng:value>
            <rng:value>fixture</rng:value>
            <rng:value>machine</rng:value>
            <rng:value>path</rng:value>
            <rng:value>powerAndFree</rng:value>
            <rng:value>station</rng:value>
            <rng:value>tool</rng:value>
            <rng:value>transporter</rng:value>
            <rng:value>other</rng:value>
        </rng:choice>
</rng:define>

<rng:define name="OrderStatus">
        <rng:choice>
            <rng:value>created</rng:value>
            <rng:value>released</rng:value>
            <rng:value>completed</rng:value>
            <rng:value>shipped</rng:value>
            <rng:value>cancelled</rng:value>
            <rng:value>unknown</rng:value>
        </rng:choice>
</rng:define>
```

```
<rng:define name="ConnectionType">
	<rng:choice>
		<rng:value>input</rng:value>
		<rng:value>output</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="CostCategory">
	<rng:choice>
		<rng:value>indirect</rng:value>
		<rng:value>labor</rng:value>
		<rng:value>material</rng:value>
		<rng:value>equipment</rng:value>
		<rng:value>other</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="CostType">
	<rng:choice>
		<rng:value>fixed</rng:value>
		<rng:value>variable</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="PartProductionStatus">
	<rng:choice>
		<rng:value>unknown</rng:value>
		<rng:value>workInProcess</rng:value>
		<rng:value>finishedGood</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="JobStatus">
	<rng:choice>
		<rng:value>released</rng:value>
		<rng:value>started</rng:value>
		<rng:value>unknown</rng:value>
		<rng:value>completed</rng:value>
		<rng:value>cancelled</rng:value>
		<rng:value>blocked</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="PrecedenceRelationship">
	<rng:choice>
		<rng:value>SS</rng:value>
		<rng:value>SF</rng:value>
		<rng:value>FS</rng:value>
		<rng:value>FF</rng:value>
	</rng:choice>
</rng:define>

<rng:define name="ResourceStatus">
	<rng:choice>
		<rng:value>busy</rng:value>
		<rng:value>idle</rng:value>
```

```
                <rng:value>broken</rng:value>
                <rng:value>underMaintenance</rng:value>
                <rng:value>unknown</rng:value>
            </rng:choice>
        </rng:define>

        <rng:define name="Day">
            <rng:choice>
                <rng:value>sunday</rng:value>
                <rng:value>monday</rng:value>
                <rng:value>tuesday</rng:value>
                <rng:value>wednesday</rng:value>
                <rng:value>thursday</rng:value>
                <rng:value>friday</rng:value>
                <rng:value>saturday</rng:value>
            </rng:choice>
        </rng:define>

        <rng:define name="InventoryItemType">
            <rng:choice>
                <rng:value>part</rng:value>
                <rng:value>resource</rng:value>
            </rng:choice>
        </rng:define>

        <rng:define name="ProcessGroupType">
            <rng:choice>
                <rng:value>sequence</rng:value>
                <rng:value>concurrent</rng:value>
                <rng:value>decision</rng:value>
            </rng:choice>
        </rng:define>
    </rng:grammar>
```

6.3 Basic Structures Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

      <!-- ************************************************************************

            Basic structures for measured values and their units

         ************************************************************************
         -->

      <rng:define name="AreaType">
            <rng:interleave>
                  <rng:optional>
                        <rng:element name="Unit">
                              <rng:ref name="AreaUnit"/>
                        </rng:element>
                  </rng:optional>
                  <rng:element name="Value">
                        <rng:ref name="Decimal"/>
                  </rng:element>
            </rng:interleave>
      </rng:define>


      <rng:define name="CurrencyType">
            <rng:interleave>
                  <rng:optional>
                        <rng:element name="Unit">
                              <rng:ref name="CurrencyUnit"/>
                        </rng:element>
                  </rng:optional>
                  <rng:element name="Value">
                        <rng:ref name="Decimal"/>
                  </rng:element>
            </rng:interleave>
      </rng:define>


      <rng:define name="ElapsedTimeType">
            <rng:interleave>
                  <rng:optional>
                        <rng:element name="Unit">
                              <rng:ref name="TimeUnit"/>
                        </rng:element>
                  </rng:optional>
                  <rng:element name="Value">
                        <rng:ref name="Decimal"/>
                  </rng:element>
            </rng:interleave>
      </rng:define>

      <rng:define name="LengthType">
            <rng:interleave>
```

```
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="LengthUnit"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="PowerType">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="PowerUnit"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="SpeedType">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="SpeedUnit"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="TemperatureType">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="TemperatureUnit"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="VolumeType">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="VolumeUnit"/>
                </rng:element>
```

```
            </rng:optional>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="WeightType">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="WeightUnit"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="QuantityType">
        <rng:interleave>
            <rng:optional>
                <rng:element name="UnitDescription">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>

            <rng:element name="UnitName">
                <rng:ref name="String"/>
            </rng:element>
            <rng:element name="Value">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>


<rng:define name="GrossDimensions">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="LengthUnit"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Width">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Depth">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
```

```
                <rng:element name="Height">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>


        <!-- ********************************************************************************

        Basic structures for Property attributes

    ********************************************************************************
    -->

<rng:define name="Property">
        <rng:interleave>
            <rng:optional>
                <rng:element name="PropertyDescription">
                    <rng:ref name="PropertyDescriptionReference"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Name">
                <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:choice>
                <rng:element name="Value">
                    <rng:ref name="String"/>
                </rng:element>
                <rng:element name="Distribution">
                    <rng:ref name="Distribution"/>
                </rng:element>
                <rng:ref name="AbstractEntityReference"/>
            </rng:choice>
        </rng:interleave>
</rng:define>

        <!-- ********************************************************************************

        Basic structures for Distribution related information

    ********************************************************************************
    -->


<rng:define name="DistributionDefinition">
```

```
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:element name="Distribution">
                <rng:ref name="Distribution"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="Duration">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Unit">
                    <rng:ref name="TimeUnit"/>
                </rng:element>
            </rng:optional>
            <rng:choice>
                <rng:element name="Value">
                    <rng:ref name="Decimal"/>
                </rng:element>
                <rng:element name="Distribution">
                    <rng:ref name="Distribution"/>
                </rng:element>
                <rng:element name="DistributionReference">
                    <rng:ref name="DistributionDefinitionReference"/>
                </rng:element>
            </rng:choice>
        </rng:interleave>
    </rng:define>

    <rng:define name="Distribution">
        <rng:interleave>
            <rng:element name="Name">
                <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:oneOrMore>
                <rng:element name="DistributionParameter">
                    <rng:ref name="DistributionParameter"/>
                </rng:element>
            </rng:oneOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="DistributionParameter">
        <rng:interleave>
            <rng:element name="Name">
                <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
```

```
            </rng:optional>
            <rng:element name="Value">
                  <rng:ref name="Decimal"/>
            </rng:element>
      </rng:interleave>
</rng:define>


<!-- ********************************************************************************

      Basic structures for Contact  related information

   ********************************************************************************
   -->

<rng:define name="ContactInformation">
      <rng:interleave>
            <rng:zeroOrMore>
                  <rng:element name="ContactParty">
                        <rng:ref name="ContactParty"/>
                  </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                  <rng:ref name="CommunicationMethod"/>
            </rng:zeroOrMore>
      </rng:interleave>
</rng:define>


<rng:define name="ContactParty">
      <rng:interleave>
            <rng:optional>
                  <rng:element name="PersonName">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="OrganizationName">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                  <rng:ref name="CommunicationMethod"/>
            </rng:zeroOrMore>
      </rng:interleave>
</rng:define>


<rng:define name="CommunicationMethod">
      <rng:choice>
            <rng:element name="Phone">
                  <rng:ref name="Phone"/>
            </rng:element>
            <rng:element name="Address">
                  <rng:ref name="Address"/>
            </rng:element>
```

```
            <rng:element name="Email">
                <rng:ref name="Email"/>
            </rng:element>
        </rng:choice>
    </rng:define>

    <rng:define name="CommunicationMethodDescriptionElement">
        <rng:optional>
            <rng:element name="Description">
                <rng:ref name="String"/>
            </rng:element>
        </rng:optional>
    </rng:define>


    <rng:define name="Phone">
        <rng:interleave>
            <rng:ref name="CommunicationMethodDescriptionElement"/>
            <rng:element name="Number">
                <rng:ref name="String"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="Email">
        <rng:interleave>
            <rng:ref name="CommunicationMethodDescriptionElement"/>
            <rng:element name="Address">
                <rng:ref name="URI"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="Address">
        <rng:interleave>
            <rng:ref name="CommunicationMethodDescriptionElement"/>
            <rng:optional>
                <rng:element name="OrganizationName">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:choice>
                <rng:element name="Street">
                    <rng:ref name="String"/>
                </rng:element>
                <rng:element name="PostOfficeBox">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:choice>
            <rng:optional>
                <rng:element name="AdditionalInformation">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:element name="City">
                <rng:ref name="String"/>
```

```
            </rng:element>
            <rng:element name="State">
                  <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                  <rng:element name="Country">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="PostalCode">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
      </rng:interleave>
</rng:define>


<!-- ********************************************************************************

      Basic structures for Precedence Constraint related information

   ********************************************************************************
   -->

<rng:define name="PrecedenceConstraintSuperClassElements">
      <rng:interleave>
            <rng:optional>
                  <rng:element name="Description">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:element name="PrecedenceRelationship">
                  <rng:ref name="PrecedenceRelationship"/>
            </rng:element>
            <rng:optional>
                  <rng:element name="LagDuration">
                        <rng:ref name="ElapsedTimeType"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="LagPercentage">
                        <rng:ref name="Decimal"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="LagPartsComplete">
                        <rng:ref name="NonNegativeInteger"/>
                  </rng:element>
            </rng:optional>
      </rng:interleave>
</rng:define>


<rng:define name="ProcessConstraint">
      <rng:interleave>
```

```
            <rng:ref name="PrecedenceConstraintSuperClassElements"/>
            <rng:element name="PredecessorProcess">
                <rng:ref name="ProcessReference"/>
            </rng:element>
            <rng:element name="SuccessorProcess">
                <rng:ref name="ProcessReference"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="JobConstraint">
        <rng:interleave>
            <rng:ref name="PrecedenceConstraintSuperClassElements"/>
            <rng:element name="PredecessorJob">
                <rng:ref name="JobReference"/>
            </rng:element>
            <rng:element name="SuccessorJob">
                <rng:ref name="JobReference"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="MaintenanceProcessConstraint">
        <rng:interleave>
            <rng:ref name="PrecedenceConstraintSuperClassElements"/>
            <rng:element name="PredecessorProcess">
                <rng:ref name="MaintenanceProcessReference"/>
            </rng:element>
            <rng:element name="SuccessorProcess">
                <rng:ref name="MaintenanceProcessReference"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<!-- ********************************************************************************

        Basic structures that support Order, Job, and Process definition

    ********************************************************************************
    -->

<rng:define name="ItemPackaging">
        <rng:interleave>
            <rng:element name="PackageName">
                <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                <rng:element name="PackageDescription">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:choice>
                    <rng:element name="PerMeasuredAmountPackaging">
                        <rng:ref name="PerMeasuredAmountPackaging"/>
                    </rng:element>
```

```
                    <rng:element name="PerPiecePackaging">
                        <rng:ref name="PerPiecePackaging"/>
                    </rng:element>
                </rng:choice>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="PerPiecePackaging">
        <rng:interleave>
            <rng:element name="PiecesPerPackage">
                <rng:ref name="NonNegativeInteger"/>
            </rng:element>
            <rng:optional>
                <rng:element name="PricePerPiece">
                    <rng:ref name="CurrencyType"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>

    </rng:define>

    <rng:define name="PerMeasuredAmountPackaging">
        <rng:interleave>
            <rng:element name="MeasuredAmount">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:optional>
                <rng:element name="PackageUnitOfMeasure">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="PricePerUnit">
                    <rng:ref name="CurrencyType"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="CostAllocationData">
        <rng:interleave>
            <rng:optional>
                <rng:element name="CostCategory">
                    <rng:ref name="CostCategory"/>
                </rng:element>
            </rng:optional>
            <rng:element name="CostType">
                <rng:ref name="CostType"/>
            </rng:element>
            <rng:optional>
                <rng:element name="CostName">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
```

```
                <rng:element name="CostDescription">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:element name="TotalCost">
                <rng:ref name="CurrencyType"/>
            </rng:element>
            <rng:zeroOrMore>
                <rng:element name="Property">
                    <rng:ref name="Property"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="VariableCostData">
                    <rng:ref name="VariableCostData"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="VariableCostData">
        <rng:interleave>
            <rng:element name="CostUnit">
                <rng:ref name="String"/>
            </rng:element>
            <rng:element name="CostRatePerUnit">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:element name="CostUnitQuantity">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="MachineProgramData">
        <rng:interleave>
            <rng:optional>
                <rng:element name="MachineProgramName">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="TargetMachine">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="MachineProgramLocation">
                    <rng:ref name="URI"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="Event">
        <rng:interleave>
```

```
            <rng:optional>
                <rng:element name="SequenceNumber">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Name">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Timestamp">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="Property">
                    <rng:ref name="Property"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <!-- ********************************************************************************

        Basic structures that support Layout information definition

       ********************************************************************************
       -->

    <rng:define name="SpatialDimension">
        <rng:interleave>
            <rng:element name="Width">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:element name="Depth">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Height">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>


    <rng:define name="BoundaryDefinition">
        <rng:interleave>
            <rng:ref name="SpatialDimension"/>
            <rng:optional>
```

```
                <rng:element name="Unit">
                    <rng:ref name="LayoutLengthUnit"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="CoordinateSystem">
                    <rng:ref name="CoordinateSystem"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

<rng:define name="Coordinate2D">
        <rng:interleave>
            <rng:element name="X">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:element name="Y">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="Coordinate3D">
        <rng:interleave>
            <rng:ref name="Coordinate2D"/>
            <rng:optional>
                <rng:element name="Z">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

<rng:define name="ColorHighlight">
        <rng:interleave>
            <rng:optional>
                <rng:element name="LineColor">
                    <rng:ref name="ColorDefinition"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="FillColor">
                    <rng:ref name="ColorDefinition"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="AlphaValue">
                    <rng:ref name="NonNegativeInteger"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="Property">
                    <rng:ref name="Property"/>
                </rng:element>
            </rng:zeroOrMore>
```

```
        </rng:interleave>
    </rng:define>

    <rng:define name="ShapeLabelDefinition">
        <rng:interleave>
            <rng:element name="Text">
                <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Color">
                    <rng:ref name="ColorDefinition"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="Property">
                    <rng:ref name="Property"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="ImageResolution">
        <rng:interleave>
            <rng:element name="PixelsPerUnit">
                <rng:ref name="NonNegativeInteger"/>
            </rng:element>
            <rng:element name="ScreenUnit">
                <rng:ref name="LayoutLengthUnit"/>
            </rng:element>
        </rng:interleave>
    </rng:define>


    <!-- ********************************************************************************

        Basic structures that support ReferenceMaterial definition

       ********************************************************************************
       -->



    <rng:define name="ReferenceMaterial">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="FileName">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="OnlineLocation">
                    <rng:ref name="URI"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
```

```
                <rng:element name="ISBN">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="DigitalFormat">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="PermanentStorageMedium">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="PhysicalLocation">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="RequiredApplication">
                    <rng:ref name="RequiredApplication"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="RequiredApplication">
        <rng:interleave>
            <rng:element name="Name">
                <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Version">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="OperatingSystem">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <!-- ********************************************************************************

        Other Basic structures

    ********************************************************************************
    -->
```

```
<rng:define name="PartGroup">
	<rng:interleave>
		<rng:optional>
			<rng:element name="Description">
				<rng:ref name="String"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="PartType">
				<rng:ref name="PartTypeReference"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="PartQuantity">
				<rng:ref name="NonNegativeInteger"/>
			</rng:element>
		</rng:optional>
		<rng:zeroOrMore>
			<rng:element name="PartInstance">
				<rng:ref name="PartReference"/>
			</rng:element>
		</rng:zeroOrMore>
	</rng:interleave>
</rng:define>

<rng:define name="LotInformation">
	<rng:interleave>
		<rng:element name="LotNumber">
			<rng:ref name="String"/>
		</rng:element>
		<rng:optional>
			<rng:element name="ParentLotNumber">
				<rng:ref name="String"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="Description">
				<rng:ref name="String"/>
			</rng:element>
		</rng:optional>
	</rng:interleave>
</rng:define>

<rng:define name="LocationDefinition">
	<rng:interleave>
		<rng:optional>
			<rng:element name="FacilityLocation">
				<rng:ref name="String"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="WithinFacilityLocation">
				<rng:ref name="String"/>
			</rng:element>
		</rng:optional>
```

```
            <rng:optional>
                <rng:element name="ResourceLocation">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>


    <rng:define name="ResourcesRequired">
        <rng:interleave>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ResourceClass">
                    <rng:ref name="ResourceClassReference"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="MinimumNumber">
                    <rng:ref name="NonNegativeInteger"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="MaximumNumber">
                    <rng:ref name="NonNegativeInteger"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="Resource">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="AllowableSetup">
                    <rng:ref name="SetupDefinitionReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="RequiredEmployeeSkill">
                    <rng:ref name="SkillReference"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

</rng:grammar>
```

6.4 Entity Reference Definition Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">


      <!--   The AbstractEntityReference type is the "supertype" for
               all entity reference types
      -->
      <rng:define name="AbstractEntityReference">
            <rng:choice>
                  <rng:element name="BillOfMaterialsReference">
                        <rng:ref name="BillOfMaterialsReference"/>
                  </rng:element>
                  <rng:element name="DistributionDefinitionReference">
                        <rng:ref name="DistributionDefinitionReference"/>
                  </rng:element>
                  <rng:element name="InventoryItemReference">
                        <rng:ref name="InventoryItemReference"/>
                  </rng:element>
                  <rng:element name="InventoryItemClassReference">
                        <rng:ref name="InventoryItemClassReference"/>
                  </rng:element>
                  <rng:element name="JobReference">
                        <rng:ref name="JobReference"/>
                  </rng:element>
                  <rng:element name="LayoutElementReference">
                        <rng:ref name="LayoutElementReference"/>
                  </rng:element>
                  <rng:element name="MaintenancePlanReference">
                        <rng:ref name="MaintenancePlanReference"/>
                  </rng:element>
                  <rng:element name="PartReference">
                        <rng:ref name="PartReference"/>
                  </rng:element>
                  <rng:element name="PartTypeReference">
                        <rng:ref name="PartTypeReference"/>
                  </rng:element>
                  <rng:element name="ProcessPlanReference">
                        <rng:ref name="ProcessPlanReference"/>
                  </rng:element>
                  <rng:element name="PropertyDescriptionReference">
                        <rng:ref name="PropertyDescriptionReference"/>
                  </rng:element>
                  <rng:element name="ReferenceMaterialReference">
                        <rng:ref name="ReferenceMaterialReference"/>
                  </rng:element>
                  <rng:element name="ResourceClassReference">
                        <rng:ref name="ResourceClassReference"/>
                  </rng:element>
                  <rng:element name="ResourceReference">
                        <rng:ref name="ResourceReference"/>
                  </rng:element>
                  <rng:element name="SetupChangeoverReference">
                        <rng:ref name="SetupChangeoverReference"/>
```

```
            </rng:element>
            <rng:element name="SetupDefinitionReference">
                <rng:ref name="SetupDefinitionReference"/>
            </rng:element>
            <rng:element name="CalendarReference">
                <rng:ref name="CalendarReference"/>
            </rng:element>
            <rng:element name="OrderInformationReference">
                <rng:ref name="OrderInformationReference"/>
            </rng:element>
            <rng:element name="SkillReference">
                <rng:ref name="SkillReference"/>
            </rng:element>
            <rng:element name="ScheduleInformationReference">
                <rng:ref name="ScheduleInformationReference"/>
            </rng:element>
            <rng:element name="ProcessReference">
                <rng:ref name="ProcessReference"/>
            </rng:element>
            <rng:element name="MaintenanceProcessReference">
                <rng:ref name="MaintenanceProcessReference"/>
            </rng:element>
            <rng:element name="BillOfMaterialsComponentReference">
                <rng:ref name="BillOfMaterialsComponentReference"/>
            </rng:element>
        </rng:choice>
    </rng:define>


    <!--    A DocumentIdentifier element should be included in all subtypes of the
AbstractEntityReference type
        -->
    <rng:define name="DocumentIdentifier">
        <rng:optional>
            <rng:element name="DocumentIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:optional>
    </rng:define>

    <!-- ********************************************************************************

        Definitions for basic entity reference classes

      ********************************************************************************
      -->
    <rng:define name="BillOfMaterialsReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="BillOfMaterialsIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="DistributionDefinitionReference">
```

```
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="DistributionDefinitionIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="InventoryItemReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="InventoryItemIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="InventoryItemClassReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="InventoryItemClassIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="JobReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="JobIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="LayoutElementReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="LayoutElementIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="MaintenancePlanReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="MaintenancePlanIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="PartReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
```

```
            <rng:element name="PartIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="PartTypeReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="PartTypeIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>
    <rng:define name="ProcessPlanReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="ProcessPlanIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="PropertyDescriptionReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="PropertyDescriptionIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="ReferenceMaterialReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="ReferenceMaterialIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="ResourceClassReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="ResourceClassIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>
    <rng:define name="ResourceReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="ResourceIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
```

```
    </rng:define>

    <rng:define name="SetupChangeoverReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="SetupChangeoverIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="SetupDefinitionReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="SetupDefinitionIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <!-- ********************************************************************************

        Definitions for complex entity reference classes

      ********************************************************************************
      -->
    <rng:define name="CalendarReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="CalendarIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
            <!--At most one of [ShiftIdentifier, ShiftScheduleIdentifier, HolidayIdentifier] must be
present -->
            <rng:optional>
                <rng:choice>
                    <rng:element name="ShiftScheduleIdentifier">
                        <rng:ref name="Identifier"/>
                    </rng:element>
                    <rng:element name="ShiftIdentifier">
                        <rng:ref name="Identifier"/>
                    </rng:element>
                    <rng:element name="HolidayIdentifier">
                        <rng:ref name="Identifier"/>
                    </rng:element>
                </rng:choice>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="OrderInformationReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="OrderIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
```

```
            <rng:optional>
                <rng:element name="OrderLineIdentifier">
                    <rng:ref name="Identifier"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="SkillReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="SkillDefinitionIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
            <rng:optional>
                <rng:element name="SkillLevelIdentifier">
                    <rng:ref name="Identifier"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="ScheduleInformationReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <rng:element name="ScheduleIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
            <rng:optional>
                <rng:element name="ScheduleItemIdentifier">
                    <rng:ref name="Identifier"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="ProcessReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <!-- at least one of [ProcessPlanIdentifier, ProcessIdentifier] must be present -->
            <rng:choice>
                <rng:element name="ProcessPlanIdentifier">
                    <rng:ref name="Identifier"/>
                </rng:element>
                <rng:interleave>
                    <rng:optional>
                        <rng:element name="ProcessPlanIdentifier">
                            <rng:ref name="Identifier"/>
                        </rng:element>
                    </rng:optional>
                    <rng:element name="ProcessIdentifier">
                        <rng:ref name="Identifier"/>
                    </rng:element>
                </rng:interleave>
            </rng:choice>
        </rng:interleave>
```

```
    </rng:define>

    <rng:define name="MaintenanceProcessReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <!-- At least one of [MaintenancePlanIdentifier, MaintenanceProcessIdentifier] must be
present
                 -->
            <rng:choice>
                <rng:element name="MaintenancePlanIdentifier">
                    <rng:ref name="Identifier"/>
                </rng:element>
                <rng:interleave>
                    <rng:optional>
                        <rng:element name="MaintenancePlanIdentifier">
                            <rng:ref name="Identifier"/>
                        </rng:element>
                    </rng:optional>
                    <rng:element name="MaintenanceProcessIdentifier">
                        <rng:ref name="Identifier"/>
                    </rng:element>
                </rng:interleave>
            </rng:choice>
        </rng:interleave>
    </rng:define>

    <rng:define name="BillOfMaterialsComponentReference">
        <rng:interleave>
            <rng:ref name="DocumentIdentifier"/>
            <!—
            At least one of
            [BillOfMaterialsIdentifier, BillOfMaterialsComponentIdentifier]
            must be present -->
            <rng:choice>
                <rng:element name="BillOfMaterialsIdentifier">
                    <rng:ref name="Identifier"/>
                </rng:element>
                <rng:interleave>
                    <rng:optional>
                        <rng:element name="BillOfMaterialsIdentifier">
                            <rng:ref name="Identifier"/>
                        </rng:element>
                    </rng:optional>
                    <rng:element name="BillOfMaterialsComponentIdentifier">
                        <rng:ref name="Identifier"/>
                    </rng:element>
                </rng:interleave>
            </rng:choice>
        </rng:interleave>
    </rng:define>
</rng:grammar>
```

6.5 Conceptual Framework Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

      <a:documentation>
            Schema representations of the Entity, LimitedUniqueEntity, and
            ReferencingEntity are not needed to define valid CMSD documents.
      </a:documentation>

      <rng:define name="IdentifiableEntity">
            <a:documentation>
             Patterns that represent CMSD classes that are subclasses of the UniqueEntity
             or LimitedUniqueEntity classes should include a reference to this pattern to
             properly model the child elements inherited by those Subclasses.
            </a:documentation>

            <rng:interleave>
                  <rng:element name="Identifier">
                        <rng:ref name="Identifier"/>
                  </rng:element>
                  <rng:optional>
                        <rng:element name="Description">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:zeroOrMore>
                        <rng:element name="ReferenceMaterial">
                              <rng:ref name="ReferenceMaterialReference"/>
                        </rng:element>
                  </rng:zeroOrMore>
                  <rng:zeroOrMore>
                        <rng:element name="Property">
                              <rng:ref name="Property"/>
                        </rng:element>
                  </rng:zeroOrMore>
            </rng:interleave>
      </rng:define>

      <rng:define name="UniqueEntity">
            <rng:choice>
                  <rng:element name="DistributionDefinition">
                        <rng:ref name="DistributionDefinition"/>
                  </rng:element>
                  <rng:element name="ReferenceMaterial">
                        <rng:ref name="ReferenceMaterial"/>
                  </rng:element>
                  <rng:element name="LayoutObject">
                        <rng:ref name="LayoutObject"/>
                  </rng:element>
                  <rng:element name="Layout">
                        <rng:ref name="Layout"/>
                  </rng:element>
                  <rng:element name="PartType">
```

```
                <rng:ref name="PartType"/>
            </rng:element>
            <rng:element name="Part">
                <rng:ref name="Part"/>
            </rng:element>
            <rng:element name="BillOfMaterials">
                <rng:ref name="BillOfMaterials"/>
            </rng:element>
            <rng:element name="InventoryItem">
                <rng:ref name="InventoryItem"/>
            </rng:element>
            <rng:element name="InventoryItemClass">
                <rng:ref name="InventoryItemClass"/>
            </rng:element>
            <rng:element name="Job">
                <rng:ref name="Job"/>
            </rng:element>
            <rng:element name="Order">
                <rng:ref name="Order"/>
            </rng:element>
            <rng:element name="Schedule">
                <rng:ref name="Schedule"/>
            </rng:element>
            <rng:element name="Calendar">
                <rng:ref name="Calendar"/>
            </rng:element>
            <rng:element name="ProcessPlan">
                <rng:ref name="ProcessPlan"/>
            </rng:element>
            <rng:element name="MaintenancePlan">
                <rng:ref name="MaintenancePlan"/>
            </rng:element>
            <rng:element name="ResourceClass">
                <rng:ref name="ResourceClass"/>
            </rng:element>
            <rng:element name="Resource">
                <rng:ref name="Resource"/>
            </rng:element>
            <rng:element name="SkillDefinition">
                <rng:ref name="SkillDefinition"/>
            </rng:element>
            <rng:element name="SetupDefinition">
                <rng:ref name="SetupDefinition"/>
            </rng:element>
            <rng:element name="SetupChangeoverDefinition">
                <rng:ref name="SetupChangeoverDefinition"/>
            </rng:element>
        </rng:choice>
    </rng:define>
</rng:grammar>
```

6.6 Metadata Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">
      <rng:define name="PropertyDescription">
            <rng:interleave>
                  <rng:optional>
                        <rng:element name="Identifier">
                              <rng:ref name="Identifier"/>
                        </rng:element>
                  </rng:optional>
                  <rng:element name="Name">
                        <rng:ref name="String"/>
                  </rng:element>
                  <rng:optional>
                        <rng:element name="Description">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:element name="ParentEntityName">
                        <rng:ref name="PropertyExtensibleEntity"/>
                  </rng:element>
                  <rng:optional>
                        <rng:element name="UnitType">
                              <rng:ref name="UnitTypeName"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="PropertyCardinality">
                              <rng:ref name="PropertyCardinality"/>
                        </rng:element>
                  </rng:optional>
                  <rng:oneOrMore>
                        <rng:element name="PropertyDataTypeDescription">
                              <rng:ref name="PropertyDataTypeDescription"/>
                        </rng:element>
                  </rng:oneOrMore>
            </rng:interleave>
      </rng:define>
      <rng:define name="PropertyDataTypeDescription">
            <rng:interleave>
                  <rng:choice>
                        <rng:element name="PropertyDataType">
                              <rng:value>stochastic</rng:value>
                        </rng:element>
                        <rng:interleave>
                              <rng:element name="PropertyDataType">
                                    <rng:value>simple</rng:value>
                              </rng:element>
                              <rng:element name="SimpleValueDataType">
                                    <rng:ref name="SimpleDataTypeName"/>
                              </rng:element>
                        </rng:interleave>
                        <rng:interleave>
                              <rng:element name="PropertyDataType">
```

```
                        <rng:value>reference</rng:value>
                    </rng:element>
                    <rng:element name="ReferenceType">
                        <rng:ref name="ReferenceTypeName"/>
                    </rng:element>
                </rng:interleave>
            </rng:choice>
        </rng:interleave>
    </rng:define>
    <rng:define name="PropertyCardinality">
        <!--  At least one of the subelements [Minimum, Maximum] must appear  -->
        <rng:choice>
            <rng:element name="Minimum">
                <rng:ref name="NonNegativeInteger"/>
            </rng:element>
            <rng:interleave>
                <rng:optional>
                    <rng:element name="Minimum">
                        <rng:ref name="NonNegativeInteger"/>
                    </rng:element>
                </rng:optional>
                <rng:element name="Maximum">
                    <rng:ref name="CardinalitySpecification"/>
                </rng:element>
            </rng:interleave>
        </rng:choice>
    </rng:define>
</rng:grammar>
```

6.7 Document Definition Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

      <rng:define name="CMSDDocument">

            <rng:zeroOrMore>
                  <a:documentation>
                    Attributes on the root(CMSDDocument) element are allowed but ignored.
                  </a:documentation>
                  <rng:attribute>
                        <rng:anyName/>
                  </rng:attribute>
            </rng:zeroOrMore>

            <rng:choice>
                  <a:documentation>
                    This pattern enforces the non-empty CMSDDocument element constraint.
                  </a:documentation>
                  <rng:element name="HeaderSection" >
                        <rng:ref name="HeaderSection"/>
                  </rng:element>
                  <rng:interleave>
                        <rng:optional>
                              <rng:element name="HeaderSection" >
                                    <rng:ref name="HeaderSection"/>
                              </rng:element>
                        </rng:optional>
                              <rng:element name="DataSection">
                                    <rng:ref name="DataSection"/>
                              </rng:element>
                  </rng:interleave>
            </rng:choice>
      </rng:define>


      <rng:define name="HeaderSection">
            <rng:interleave>
                  <rng:optional>
                        <rng:element name="DocumentIdentifier" >
                              <rng:ref name="Identifier"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="Description">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="Version">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
```

```
                <rng:element name="CreationTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Metadata">
                    <rng:ref name="Metadata"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="CMSDDocumentReference">
                    <rng:ref name="CMSDDocumentReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="UnitDefaults">
                    <rng:ref name="UnitDefaults"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

<rng:define name="DataSection">
        <rng:oneOrMore>
            <rng:ref name="UniqueEntity"/>
        </rng:oneOrMore>
</rng:define>

<rng:define name="Metadata">
        <rng:oneOrMore>
            <rng:element name="PropertyDescription">
                <rng:ref name="PropertyDescription"/>
            </rng:element>
        </rng:oneOrMore>
</rng:define>

<rng:define name="CMSDDocumentReference" >
            <rng:interleave>
            <rng:element name="LocalDocumentIdentifier">
                <rng:ref name="Identifier"/>
            </rng:element>
            <rng:element name="DocumentLocation">
                <rng:ref name="URI"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>

</rng:define>

<rng:define name="UnitDefaults">
        <rng:interleave>
```

```
        <a:documentation>default value is : squareFoot</a:documentation>
        <rng:optional>
            <rng:element name="AreaUnit">
                <rng:ref name="AreaUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : foot</a:documentation>
        <rng:optional>
            <rng:element name="LengthUnit">
                <rng:ref name="LengthUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : USD</a:documentation>
        <rng:optional>
            <rng:element name="CurrencyUnit">
                <rng:ref name="String"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : horsepower</a:documentation>
        <rng:optional>
            <rng:element name="PowerUnit">
                <rng:ref name="PowerUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : footPerSecond</a:documentation>
        <rng:optional>
            <rng:element name="SpeedUnit">
                <rng:ref name="SpeedUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : Fahrenheit</a:documentation>
        <rng:optional>
            <rng:element name="TemperatureUnit">
                <rng:ref name="TemperatureUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : minute</a:documentation>
        <rng:optional>
            <rng:element name="TimeUnit">
                <rng:ref name="TimeUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : cubicFoot</a:documentation>
        <rng:optional>
            <rng:element name="VolumeUnit">
                <rng:ref name="VolumeUnit"/>
            </rng:element>
        </rng:optional>
        <a:documentation>default value is : pound</a:documentation>
        <rng:optional>
            <rng:element name="WeightUnit">
                <rng:ref name="WeightUnit"/>
            </rng:element>
        </rng:optional>
    </rng:interleave>
```

```
    </rng:define>
</rng:grammar>
```

6.8 Part Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

      <!-- ***************************************************************************

            Definitions for Part and PartType

         ***************************************************************************
         -->

      <rng:define name="PartType">

            <rng:interleave>
                  <rng:ref name="IdentifiableEntity"/>
                  <rng:optional>
                        <rng:element name="Name">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="BillOfMaterials">
                              <rng:ref name="BillOfMaterialsReference"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="ProcessPlan">
                              <rng:ref name="ProcessPlanReference"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="Size">
                              <rng:ref name="GrossDimensions"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="Weight">
                              <rng:ref name="WeightType"/>
                        </rng:element>
                  </rng:optional>
            </rng:interleave>
      </rng:define>



      <rng:define name="Part">
            <rng:interleave>

                  <rng:ref name="IdentifiableEntity"/>
                  <rng:optional>
                        <rng:element name="PartType">
                              <rng:ref name="PartTypeReference"/>
                        </rng:element>
                  </rng:optional>
```

```
            <rng:optional>
                  <rng:element name="Name">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="ProductionStatus">
                        <rng:ref name="PartProductionStatus"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="Location">
                        <rng:ref name="LocationDefinition"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="BillOfMaterials">
                        <rng:ref name="BillOfMaterialsReference"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="ProcessPlan">
                        <rng:ref name="ProcessPlanReference"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="LastFinishedProcessStep">
                        <rng:ref name="ProcessReference"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="Size">
                        <rng:ref name="GrossDimensions"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="Weight">
                        <rng:ref name="WeightType"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="Lot">
                        <rng:ref name="LotInformation"/>
                  </rng:element>
            </rng:optional>
      </rng:interleave>
</rng:define>

<!-- ********************************************************************************

      Definitions for BillOfMaterials and BillOfMaterialsComponent

   ********************************************************************************
   -->
```

```
<rng:define name="BillOfMaterials">
	<rng:interleave>
		<rng:ref name="IdentifiableEntity"/>
		<rng:optional>
			<rng:element name="Name">
				<rng:ref name="String"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="PartType">
				<rng:ref name="PartTypeReference"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="PartInstance">
				<rng:ref name="PartReference"/>
			</rng:element>
		</rng:optional>
		<rng:optional>
			<rng:element name="MainComponent">
				<rng:ref name="BillOfMaterialsComponentReference"/>
			</rng:element>
		</rng:optional>
		<rng:zeroOrMore>
			<rng:element name="BillOfMaterialsComponent">
				<rng:ref name="BillOfMaterialsComponent"/>
			</rng:element>
		</rng:zeroOrMore>
	</rng:interleave>
</rng:define>

<rng:define name="BillOfMaterialsComponent">

	<rng:interleave>
		<rng:ref name="IdentifiableEntity"/>
		<rng:element name="Quantity">
			<rng:ref name="Decimal"/>
		</rng:element>
		<rng:optional>
			<rng:element name="PartType">
				<rng:ref name="PartTypeReference"/>
			</rng:element>
		</rng:optional>
		<rng:zeroOrMore>
			<rng:element name="PartInstance">
				<rng:ref name="PartReference"/>
			</rng:element>
		</rng:zeroOrMore>
		<rng:zeroOrMore>
			<rng:element name="SubComponent">
				<rng:ref name="BillOfMaterialsComponentReference"/>
			</rng:element>
		</rng:zeroOrMore>
	</rng:interleave>
</rng:define>
```

```
<!-- ********************************************************************************

     Definitions for InventoryItem and InventoryItemClass

   ********************************************************************************
   -->


<rng:define name="InventoryItem">

     <rng:interleave>

          <rng:ref name="IdentifiableEntity"/>
          <rng:optional>
               <rng:element name="Name">
                    <rng:ref name="String"/>
               </rng:element>
          </rng:optional>
          <rng:element name="InventoryItemClass">
               <rng:ref name="InventoryItemClassReference"/>
          </rng:element>
          <rng:optional>
               <rng:element name="QuantityOnHand">
                    <rng:ref name="NonNegativeInteger"/>
               </rng:element>
          </rng:optional>
          <rng:optional>
               <rng:element name="Location">
                    <rng:ref name="LocationDefinition"/>
               </rng:element>
          </rng:optional>
          <rng:zeroOrMore>
               <rng:element name="AssociatedPart">
                    <rng:ref name="PartReference"/>
               </rng:element>
          </rng:zeroOrMore>
          <rng:zeroOrMore>
               <rng:element name="AssociatedResource">
                    <rng:ref name="ResourceReference"/>
               </rng:element>
          </rng:zeroOrMore>
     </rng:interleave>
</rng:define>



<rng:define name="InventoryItemClass">

     <rng:interleave>
          <rng:ref name="IdentifiableEntity"/>
          <rng:optional>
               <rng:element name="Name">
                    <rng:ref name="String"/>
               </rng:element>
          </rng:optional>
```

```
                <rng:element name="InventoryItemType">
                    <rng:ref name="InventoryItemType"/>
                </rng:element>
                <rng:choice>
                    <rng:element name="PartType">
                        <rng:ref name="PartTypeReference"/>
                    </rng:element>
                    <rng:element name="ResourceClass">
                        <rng:ref name="ResourceClassReference"/>
                    </rng:element>
                </rng:choice>
            </rng:interleave>
        </rng:define>
</rng:grammar>
```

6.9 Resource Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

      <!-- ***************************************************************************

            Definitions for Resource and ResourceClass

         ***************************************************************************
         -->

      <rng:define name="ResourceClass">
            <rng:interleave>
                  <rng:ref name="IdentifiableEntity"/>
                  <rng:element name="ResourceType">
                        <rng:ref name="ResourceType"/>
                  </rng:element>
                  <rng:optional>
                        <rng:element name="Name">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="HourlyRate">
                              <rng:ref name="CurrencyType"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="Size">
                              <rng:ref name="GrossDimensions"/>
                        </rng:element>
                  </rng:optional>
            </rng:interleave>
      </rng:define>


      <rng:define name="Resource">

            <rng:interleave>
                  <rng:ref name="IdentifiableEntity"/>
                  <rng:element name="ResourceType">
                        <rng:ref name="ResourceType"/>
                  </rng:element>
                  <rng:optional>
                        <rng:element name="ResourceClass">
                              <rng:ref name="ResourceClassReference"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="Name">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
```

```
                <rng:element name="CurrentStatus">
                    <rng:ref name="ResourceStatus"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="CurrentSetup">
                    <rng:ref name="SetupDefinitionReference"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="ShiftAssignment">
                    <rng:ref name="CalendarReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="AssociatedResource">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="HourlyRate">
                    <rng:ref name="CurrencyType"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="EmployeeSkill">
                    <rng:ref name="SkillReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="GroupDefinition">
                    <rng:ref name="ResourceGroupInformation"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Size">
                    <rng:ref name="GrossDimensions"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <!-- ********************************************************************************

        Definitions for ResourceGroupInformation and related elements

       ********************************************************************************
       -->
    <rng:define name="ResourceGroupInformation">
        <rng:interleave>
            <rng:oneOrMore>
                <rng:element name="ResourceGroupMember">
                    <rng:ref name="ResourceGroupMember"/>
                </rng:element>
            </rng:oneOrMore>
            <rng:zeroOrMore>
```

```
                <rng:element name="Connection">
                    <rng:ref name="Connection"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
</rng:define>

<rng:define name="ResourceGroupMember">
        <rng:ref name="ResourceReference"/>
</rng:define>

<rng:define name="Connection">

        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="FromResource">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ToResource">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

 <!-- ********************************************************************************

      Definitions for SkillDefinition and SkillLevel

    ********************************************************************************
    -->

<rng:define name="SkillDefinition">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="Name">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="SkillLevel">
                    <rng:ref name="SkillLevel"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
</rng:define>

<rng:define name="SkillLevel">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="Name">
```

```
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

 <!-- ********************************************************************************

      Definitions for Setup Related elements

   ********************************************************************************
   -->

<rng:define name="SetupDefinition">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:element name="SetupResource">
                <rng:ref name="ResourceReference"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Name">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="SetupComponent">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="ChildSetup">
                    <rng:ref name="SetupDefinitionReference"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
</rng:define>


<rng:define name="SetupChangeoverDefinition">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:element name="CurrentSetup">
                <rng:ref name="SetupDefinitionReference"/>
            </rng:element>
            <rng:oneOrMore>
                <rng:element name="NewSetup">
                    <rng:ref name="NewSetup"/>
                </rng:element>
            </rng:oneOrMore>
        </rng:interleave>
</rng:define>



<rng:define name="NewSetup">
        <rng:interleave>
```

```
                <rng:ref name="SetupDefinitionReference"/>
                <rng:element name="ChangeoverTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:interleave>
        </rng:define>
</rng:grammar>
```

6.10 Production Planning Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
    xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
    xmlns:sch="http://www.ascc.net/xml/schematron"
    datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

    <!-- ***************************************************************************

        Definitions for Calendar related elements

      ***************************************************************************
      -->
    <rng:define name="Calendar">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="EffectiveStartDate">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="EffectiveEndDate">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="Holiday">
                    <rng:ref name="Holiday"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="Shift">
                    <rng:ref name="Shift"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="ShiftSchedule">
                    <rng:ref name="ShiftSchedule"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="Holiday">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:element name="Date">
                <rng:ref name="Date"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="Shift">

        <rng:interleave>
```

```
            <rng:ref name="IdentifiableEntity"/>
            <rng:element name="StartTime">
                  <rng:ref name="Time"/>
            </rng:element>
            <rng:element name="Duration">
                  <rng:ref name="ElapsedTimeType"/>
            </rng:element>
            <rng:oneOrMore>
                  <rng:element name="ApplicableDay">
                        <rng:ref name="Day"/>
                  </rng:element>
            </rng:oneOrMore>
            <rng:zeroOrMore>
                  <rng:element name="Break">
                        <rng:ref name="Break"/>
                  </rng:element>
            </rng:zeroOrMore>
      </rng:interleave>
</rng:define>

<rng:define name="Break">
      <rng:interleave>
            <rng:optional>
                  <rng:element name="Description">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:element name="StartTime">
                  <rng:ref name="Time"/>
            </rng:element>
            <rng:element name="Duration">
                  <rng:ref name="ElapsedTimeType"/>
            </rng:element>
      </rng:interleave>
</rng:define>


<rng:define name="ShiftSchedule">
      <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                  <rng:element name="EffectiveStartDate">

                        <rng:ref name="Timestamp"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="EffectiveEndDate">
                        <rng:ref name="Timestamp"/>
                  </rng:element>
            </rng:optional>
            <rng:oneOrMore>
                  <rng:element name="ApplicableShift">
                        <rng:ref name="CalendarReference"/>
                  </rng:element>
            </rng:oneOrMore>
```

```
            <rng:zeroOrMore>
                <rng:element name="ApplicableHoliday">
                    <rng:ref name="CalendarReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="AvailabilityException">
                    <rng:ref name="AvailabilityException"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="AvailabilityException">
        <rng:interleave>
            <rng:element name="ExceptionDate">
                <rng:ref name="Date"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <!-- ********************************************************************************

        Definitions for ProcessPlan and MaintenencePlan related elements

      ********************************************************************************
      -->


    <rng:define name="ProcessPlan">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:oneOrMore>
                <rng:element name="PartsProduced">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:oneOrMore>
            <rng:zeroOrMore>
                <rng:element name="PartsConsumed">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="ResourcesRequired">
                    <rng:ref name="ResourcesRequired"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="CostAllocationData">
                    <rng:ref name="CostAllocationData"/>
                </rng:element>
```

```
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="FirstProcess">
                    <rng:ref name="ProcessReference"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="Process">
                    <rng:ref name="Process"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="Process">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:zeroOrMore>
                <rng:element name="PartsProduced">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="PartsConsumed">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="ResourcesRequired">
                    <rng:ref name="ResourcesRequired"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="MachineProgramInformation">
                    <rng:ref name="MachineProgramData"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="SetupTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="OperationTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="RepetitionCount">
                    <rng:ref name="Integer"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="CostAllocationData">
                    <rng:ref name="CostAllocationData"/>
                </rng:element>
```

```
            </rng:zeroOrMore>
            <rng:optional>
                  <rng:element name="SpecialInstruction">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                  <rng:element name="ProcessConstraint">
                        <rng:ref name="ProcessConstraint"/>
                  </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                  <rng:element name="SubProcessGroup">
                        <rng:ref name="ProcessGroup"/>
                  </rng:element>
            </rng:optional>
      </rng:interleave>
</rng:define>

<rng:define name="ProcessGroup">
      <rng:interleave>
            <rng:element name="Type">
                  <rng:ref name="ProcessGroupType"/>
            </rng:element>
            <rng:optional>
                  <rng:element name="DecisionText">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:oneOrMore>
                  <rng:element name="Process">
                        <rng:ref name="ProcessReference"/>
                  </rng:element>
            </rng:oneOrMore>
            <rng:zeroOrMore>
                  <rng:element name="ProcessConstraint">
                        <rng:ref name="ProcessConstraint"/>
                  </rng:element>
            </rng:zeroOrMore>
      </rng:interleave>
</rng:define>

<rng:define name="MaintenancePlan">
      <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:zeroOrMore>
                  <rng:element name="MaintainedResource">
                        <rng:ref name="ResourceReference"/>
                  </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                  <rng:element name="Periodicity">
                        <rng:ref name="Duration"/>
                  </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
```

```
                <rng:element name="CostAllocationData">
                    <rng:ref name="CostAllocationData"/>
                </rng:element>
            </rng:zeroOrMore>

            <rng:optional>
                <rng:element name="FirstProcess">
                    <rng:ref name="MaintenanceProcessReference"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="MaintenanceProcess">
                    <rng:ref name="MaintenanceProcess"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="MaintenanceProcess">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:zeroOrMore>
                <rng:element name="ResourcesRequired">
                    <rng:ref name="ResourcesRequired"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="PartsConsumed">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="SetupTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="OperationTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="RepetitionCount">
                    <rng:ref name="Integer"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="CostAllocationData">
                    <rng:ref name="CostAllocationData"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="SpecialInstruction">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
```

```
            <rng:zeroOrMore>
                <rng:element name="ProcessConstraint">
                    <rng:ref name="MaintenanceProcessConstraint"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="SubProcessGroup">
                    <rng:ref name="MaintenanceProcessGroup"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>

    <rng:define name="MaintenanceProcessGroup">
        <rng:interleave>
            <rng:element name="Type">
                <rng:ref name="ProcessGroupType"/>
            </rng:element>
            <rng:optional>
                <rng:element name="DecisionText">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:oneOrMore>
                <rng:element name="Process">
                    <rng:ref name="MaintenanceProcessReference"/>
                </rng:element>
            </rng:oneOrMore>
            <rng:zeroOrMore>
                <rng:element name="ProcessConstraint">
                    <rng:ref name="MaintenanceProcessConstraint"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>
</rng:grammar>
```

6.11 Production Operations Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
      xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
      datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

      <!-- ***************************************************************************

            Definitions for Order, Job, and related elements

         ***************************************************************************
         -->

      <rng:define name="Job">
            <rng:interleave>
                  <rng:ref name="IdentifiableEntity"/>
                  <rng:element name="Status">
                        <rng:ref name="JobStatus"/>
                  </rng:element>
                  <rng:optional>
                        <rng:element name="UpdateTime">
                              <rng:ref name="Timestamp"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="RequestingParty">
                              <rng:ref name="ContactInformation"/>
                        </rng:element>
                  </rng:optional>
                  <rng:optional>
                        <rng:element name="PerformingParty">
                              <rng:ref name="ContactInformation"/>
                        </rng:element>
                  </rng:optional>
                  <rng:zeroOrMore>
                        <rng:element name="AssociatedOrder">
                              <rng:ref name="OrderInformationReference"/>
                        </rng:element>
                  </rng:zeroOrMore>
                  <rng:optional>
                        <rng:element name="Priority">
                              <rng:ref name="String"/>
                        </rng:element>
                  </rng:optional>
                  <rng:zeroOrMore>
                        <rng:element name="PrecedenceConstraint">
                              <rng:ref name="JobConstraint"/>
                        </rng:element>
                  </rng:zeroOrMore>
                  <rng:zeroOrMore>
                        <rng:element name="SubJob">
                              <rng:ref name="JobReference"/>
                        </rng:element>
                  </rng:zeroOrMore>
                  <rng:optional>
                        <rng:element name="PlannedEffort">
```

```
                    <rng:ref name="JobEffortDescription"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ActualEffort">
                    <rng:ref name="JobEffortDescription"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

<rng:define name="JobEffortDescription">

        <rng:interleave>
            <rng:optional>
                <rng:element name="UpdateTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="PartsProduced">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="PartsConsumed">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="ResourcesRequired">
                    <rng:ref name="ResourcesRequired"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:optional>
                <rng:element name="DueDate">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ReleaseDate">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="StartTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="EndTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="SetupTime">
```

```
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ProcessingTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ProcessPlan">
                    <rng:ref name="ProcessPlanReference"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="CurrentProcessPlanStep">
                    <rng:ref name="ProcessReference"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="MaintenancePlan">
                    <rng:ref name="MaintenancePlanReference"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="CurrentMaintenancePlanStep">
                    <rng:ref name="MaintenanceProcessReference"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="CostAllocationData">
                    <rng:ref name="CostAllocationData"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="Note">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="Event">
                    <rng:ref name="Event"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="Property">
                    <rng:ref name="Property"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="Order">
        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:element name="Status">
                <rng:ref name="OrderStatus"/>
```

```
            </rng:element>
            <rng:optional>
                <rng:element name="UpdateTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="CustomerParty">
                    <rng:ref name="ContactInformation"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="SupplierParty">
                    <rng:ref name="ContactInformation"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="SpecialInstruction">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="TotalPrice">
                    <rng:ref name="CurrencyType"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="DueDate">
                    <rng:ref name="Date"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Priority">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:oneOrMore>
                <rng:element name="OrderLine">
                    <rng:ref name="OrderLine"/>
                </rng:element>
            </rng:oneOrMore>
        </rng:interleave>
    </rng:define>

    <rng:define name="OrderLine">

        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="UpdateTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Status">
                <rng:ref name="OrderStatus"/>
            </rng:element>
```

```
            <rng:element name="ItemDescription">
                <rng:ref name="String"/>
            </rng:element>
            <rng:element name="ItemQuantity">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:optional>
                <rng:element name="ItemPrice">
                    <rng:ref name="CurrencyType"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Priority">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ServiceDescription">
                    <rng:ref name="OrderLineServiceDescription"/>
                </rng:element>
                <rng:element name="PartDescription">
                    <rng:ref name="OrderLinePartDescription"/>
                </rng:element>
            </rng:choice>
        </rng:optional>
    </rng:interleave>
</rng:define>

<rng:define name="OrderLineServiceDescription">

    <rng:interleave>
        <rng:optional>
            <rng:element name="ServiceIdentifier">
                <rng:ref name="String"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="ServiceDetails">
                <rng:ref name="String"/>
            </rng:element>
        </rng:optional>
    </rng:interleave>
</rng:define>

<rng:define name="OrderLinePartDescription">

    <rng:interleave>
        <rng:optional>
            <rng:element name="PartType">
                <rng:ref name="PartTypeReference"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="Packaging">
                <rng:ref name="ItemPackaging"/>
```

```
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="PartDetails">
                <rng:ref name="String"/>
            </rng:element>
        </rng:optional>
    </rng:interleave>
</rng:define>

<!-- ********************************************************************************

    Definitions for Schedule related elements

  ********************************************************************************
  -->
<rng:define name="Schedule">
    <rng:interleave>
        <rng:ref name="IdentifiableEntity"/>
        <rng:optional>
            <rng:element name="CreationTime">
                <rng:ref name="Timestamp"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="StartTime">
                <rng:ref name="Timestamp"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="EndTime">
                <rng:ref name="Timestamp"/>
            </rng:element>
        </rng:optional>
        <rng:zeroOrMore>
            <rng:element name="ScheduleItem">
                <rng:ref name="ScheduleItem"/>
            </rng:element>
        </rng:zeroOrMore>
    </rng:interleave>
</rng:define>

<rng:define name="ScheduleItem">
    <rng:interleave>
        <rng:ref name="IdentifiableEntity"/>
        <rng:element name="Status">
            <rng:ref name="JobStatus"/>
        </rng:element>
        <rng:optional>
            <rng:choice>
                <rng:element name="AssociatedJob">
                    <rng:ref name="JobReference"/>
                </rng:element>
                <rng:element name="AssociatedOrderInformation">
                    <rng:ref name="OrderInformationReference"/>
                </rng:element>
```

```
                    <rng:element name="AssociatedProcess">
                        <rng:ref name="ProcessReference"/>
                    </rng:element>
                    <rng:element name="AssociatedProcessPlan">
                        <rng:ref name="ProcessPlanReference"/>
                    </rng:element>
                    <rng:element name="AssociatedMaintenancePlan">
                        <rng:ref name="MaintenancePlanReference"/>
                    </rng:element>
                    <rng:element name="AssociatedMaintenanceProcess">
                        <rng:ref name="MaintenanceProcessReference"/>
                    </rng:element>
                </rng:choice>
            </rng:optional>
            <rng:optional>
                <rng:element name="PlannedEffort">
                    <rng:ref name="ScheduleItemEffortDescription"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ActualEffort">
                    <rng:ref name="ScheduleItemEffortDescription"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>
    <rng:define name="ScheduleItemEffortDescription">
        <rng:interleave>
            <rng:optional>
                <rng:element name="UpdateTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:element name="StartTime">
                <rng:ref name="Timestamp"/>
            </rng:element>
            <rng:optional>
                <rng:element name="EndTime">
                    <rng:ref name="Timestamp"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="ProcessingTime">
                    <rng:ref name="Duration"/>
                </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                <rng:element name="ResourcesUsed">
                    <rng:ref name="ResourcesRequired"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="PartsUsed">
                    <rng:ref name="PartGroup"/>
                </rng:element>
            </rng:zeroOrMore>
```

```
                <rng:zeroOrMore>
                    <rng:element name="PartsProduced">
                        <rng:ref name="PartGroup"/>
                    </rng:element>
                </rng:zeroOrMore>
                <rng:zeroOrMore>
                    <rng:element name="Property">
                        <rng:ref name="Property"/>
                    </rng:element>
                </rng:zeroOrMore>
            </rng:interleave>
        </rng:define>
</rng:grammar>
```

6.12 Layout Grammar

```
<rng:grammar xmlns:rng="http://relaxng.org/ns/structure/1.0"
    xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
    datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">


    <!-- ***************************************************************************

        Definitions for LayoutElement and related elements

      ***************************************************************************
      -->
    <rng:define name="LayoutElement">

        <rng:interleave>
            <rng:ref name="IdentifiableEntity"/>
            <rng:optional>
                <rng:element name="Name">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="AssociatedResource">
                    <rng:ref name="ResourceReference"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Boundary">
                <rng:ref name="BoundaryDefinition"/>
            </rng:element>
        </rng:interleave>
    </rng:define>


    <rng:define name="LayoutObject">
        <rng:interleave>
            <rng:ref name="LayoutElement"/>
            <rng:optional>
                <rng:element name="Type">
                    <rng:ref name="ResourceType"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Shape">
                    <rng:ref name="ShapeDescription"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
    </rng:define>


    <rng:define name="Layout">
        <rng:interleave>
            <rng:ref name="LayoutElement"/>
            <rng:zeroOrMore>
                <rng:element name="Placement">
```

```
                    <rng:ref name="Placement"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
</rng:define>

<rng:define name="Placement">
        <rng:interleave>
            <rng:ref name="LayoutElementReference"/>
            <rng:element name="Location">
                <rng:ref name="Coordinate3D"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Transformations">
                    <rng:ref name="TransformationList"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>


 <!-- ********************************************************************************

      Definition for Shape Description

    ********************************************************************************
    -->

<rng:define name="ShapeDescription">

        <rng:interleave>
            <rng:element name="ShapeType">
                <rng:ref name="ShapeDescriptionType"/>
            </rng:element>
            <rng:choice>

                    <rng:element name="BasicShape">
                        <rng:choice>
                            <rng:ref name="Box"/>
                            <rng:ref name="Circle"/>
                            <rng:ref name="Polygon"/>
                        </rng:choice>
                    </rng:element>

                    <rng:element name="Graphic">
                        <rng:choice>
                            <rng:ref name="ImageGraphic"/>
                            <rng:ref name="ModelGraphic"/>
                        </rng:choice>
                    </rng:element>

                <rng:oneOrMore>
                    <rng:element name="Segment">
                        <rng:choice>
                            <rng:ref name="CurvedSegment"/>
                            <rng:ref name="StraightSegment"/>
```

```
                    </rng:choice>
                </rng:element>
            </rng:oneOrMore>

                <rng:element name="TextualAnnotation">
                    <rng:ref name="TextualAnnotation"/>
                </rng:element>

        </rng:choice>
    </rng:interleave>
</rng:define>

 <!-- ********************************************************************************

     Definitions for TransformationList and related elements

   ********************************************************************************
   -->

<rng:define name="TransformationList">
    <rng:oneOrMore>

        <rng:ref name="TransformationOperation"/>

    </rng:oneOrMore>
</rng:define>

<rng:define name="TransformationOperation" >
    <rng:choice>
        <rng:element name="Rotation">
            <rng:ref name="Rotation"/>
        </rng:element>
        <rng:element name="Translation">
            <rng:ref name="Translation"/>
        </rng:element>
        <rng:element name="Scaling">
            <rng:ref name="Scaling"/>
        </rng:element>
    </rng:choice>
</rng:define>

<rng:define name="Rotation">
    <rng:interleave>
        <rng:optional>
            <rng:element name="XDegree">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="YDegree">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="ZDegree">
                <rng:ref name="Decimal"/>
```

```
            </rng:element>
        </rng:optional>
        <rng:element name="Origin">
            <rng:ref name="Coordinate3D"/>
        </rng:element>
    </rng:interleave>
</rng:define>


<rng:define name="Translation">
    <rng:interleave>
        <rng:optional>
            <rng:element name="XOffset">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="YOffset">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="ZOffset">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
    </rng:interleave>
</rng:define>


<rng:define name="Scaling">
    <rng:interleave>
        <rng:optional>
            <rng:element name="XPercent">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="YPercent">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
        <rng:optional>
            <rng:element name="ZPercent">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:optional>
    </rng:interleave>
</rng:define>

 <!-- ********************************************************************************

     Definitions for Graphic Description and related elements

  ********************************************************************************
  -->
```

```
 <rng:define name="GraphicDescription">
      <rng:interleave>
            <rng:element name="FileName">
                  <rng:ref name="URI"/>
            </rng:element>
            <rng:element name="FileType">
                  <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                  <rng:element name="Transformations">
                        <rng:ref name="TransformationList"/>
                  </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                  <rng:element name="Property">
                        <rng:ref name="Property"/>
                  </rng:element>
            </rng:zeroOrMore>
      </rng:interleave>
</rng:define>

<rng:define name="ModelGraphic">
      <rng:interleave>
            <rng:element name="GraphicType">
                  <rng:value>modelGraphic</rng:value>
            </rng:element>
            <rng:ref name="GraphicDescription"/>
            <rng:element name="ModelUnit">
                  <rng:ref name="LayoutLengthUnit"/>
            </rng:element>
            <rng:element name="ModelDimension">
                  <rng:ref name="SpatialDimension"/>
            </rng:element>
      </rng:interleave>
</rng:define>

<rng:define name="ImageGraphic">
      <rng:interleave>
            <rng:element name="GraphicType">
                  <rng:value>imageGraphic</rng:value>
            </rng:element>
            <rng:ref name="GraphicDescription"/>
            <rng:element name="ImageResolution">
                  <rng:ref name="ImageResolution"/>
            </rng:element>
            <rng:element name="ImageDimension">
                  <rng:ref name="SpatialDimension"/>
            </rng:element>
      </rng:interleave>
</rng:define>

  <!-- ********************************************************************************

      Definition for TextualAnnotation
```

```
   ************************************************************************
   -->

<rng:define name="TextualAnnotation">
      <rng:interleave>
            <rng:optional>
                  <rng:element name="AttachPoint">
                        <rng:ref name="Coordinate3D"/>
                  </rng:element>
            </rng:optional>
            <rng:element name="Text">
                  <rng:ref name="String"/>
            </rng:element>
            <rng:optional>
                  <rng:element name="TextAnchorLocation">
                        <rng:ref name="TextAnchorLocation"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="Color">
                        <rng:ref name="ColorDefinition"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="Style">
                        <rng:ref name="String"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
                  <rng:element name="TextAngle">
                        <rng:ref name="Decimal"/>
                  </rng:element>
            </rng:optional>
            <rng:zeroOrMore>
                  <rng:element name="Property">
                        <rng:ref name="Property"/>
                  </rng:element>
            </rng:zeroOrMore>
      </rng:interleave>
</rng:define>

 <!-- ************************************************************************

      Definitions for BasicShape and related elements

   ************************************************************************
   -->

<rng:define name="BasicShape">
      <rng:interleave>
            <rng:optional>
                  <rng:element name="Height">
                        <rng:ref name="Decimal"/>
                  </rng:element>
            </rng:optional>
            <rng:optional>
```

```
                <rng:element name="Color">
                    <rng:ref name="ColorHighlight"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Label">
                    <rng:ref name="ShapeLabelDefinition"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

<rng:define name="Box">
        <rng:interleave>
            <rng:element name="Type">
                <rng:value>box</rng:value>
            </rng:element>
            <rng:ref name="BasicShape"/>
            <rng:element name="Width">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:element name="Depth">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
</rng:define>

<rng:define name="Circle">
        <rng:interleave>
            <rng:element name="Type">
                <rng:value>circle</rng:value>
            </rng:element>
            <rng:ref name="BasicShape"/>
            <rng:element name="Center">
                <rng:ref name="Coordinate2D"/>
            </rng:element>
            <rng:element name="Radius">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:optional>
                <rng:element name="Angle">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
        </rng:interleave>
</rng:define>

<rng:define name="Polygon">

        <rng:interleave>
            <rng:element name="Type">
                <rng:value>polygon</rng:value>
            </rng:element>
            <rng:ref name="BasicShape"/>
            <rng:oneOrMore>
                <rng:element name="Point">
```

```
                    <rng:ref name="Coordinate2D"/>
                </rng:element>
            </rng:oneOrMore>
        </rng:interleave>
    </rng:define>


    <!-- ********************************************************************************

        Definitions for SegmentShape and related elements

      ********************************************************************************
      -->

    <rng:define name="SegmentShape">
        <rng:interleave>
            <rng:optional>
                <rng:element name="SegmentNumber">
                    <rng:ref name="Identifier"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Description">
                    <rng:ref name="String"/>
                </rng:element>
            </rng:optional>
            <rng:element name="Base">
                <rng:ref name="BaseLocation"/>
            </rng:element>
            <rng:element name="Start">
                <rng:ref name="Coordinate2D"/>
            </rng:element>
            <rng:element name="Width">
                <rng:ref name="Decimal"/>
            </rng:element>
            <rng:optional>
                <rng:element name="StartHeight">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="EndHeight">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="TrackWidth">
                    <rng:ref name="Decimal"/>
                </rng:element>
            </rng:optional>
            <rng:optional>
                <rng:element name="Color">
                    <rng:ref name="ColorHighlight"/>
                </rng:element>
            </rng:optional>
```

```
            <rng:zeroOrMore>
                <rng:element name="ReferenceMaterial">
                    <rng:ref name="ReferenceMaterialReference"/>
                </rng:element>
            </rng:zeroOrMore>
            <rng:zeroOrMore>
                <rng:element name="Property">
                    <rng:ref name="Property"/>
                </rng:element>
            </rng:zeroOrMore>
        </rng:interleave>
    </rng:define>


    <rng:define name="StraightSegment">
        <rng:interleave>
            <rng:element name="Type">
                <rng:value>straight</rng:value>
            </rng:element>
            <rng:ref name="SegmentShape"/>
            <rng:element name="End">
                <rng:ref name="Coordinate2D"/>
            </rng:element>
        </rng:interleave>
    </rng:define>

    <rng:define name="CurvedSegment">
        <rng:interleave>
            <rng:element name="Type">
                <rng:value>curved</rng:value>
            </rng:element>
            <rng:ref name="SegmentShape"/>
            <rng:element name="RotationPoint">
                <rng:ref name="Coordinate2D"/>
            </rng:element>
            <rng:element name="RotationAngle">
                <rng:ref name="Decimal"/>
            </rng:element>
        </rng:interleave>
    </rng:define>
</rng:grammar>
```

7 The Core Manufacturing Simulation Data Schematron Schema

The definition of the CMSD Schematron schema is presented below.

```
<sch:schema xmlns:sch="http://www.ascc.net/xml/schematron">

    <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/GrossDimensions subtype usage rules">
        <sch:rule context="//DataSection/Part/Size">
            <sch:assert
                test="count(Width) + count(Depth) + count(Height) &gt; 0">
                //DataSection/Part/Size:
                    At least one of [Width,Depth,Height] must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/PartType/Size">
            <sch:assert
                test="count(Width) + count(Depth) + count(Height) &gt; 0">
                //DataSection/PartType/Size:
                    At least one of [Width,Depth,Height] must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/Resource/Size">
            <sch:assert
                test="count(Width) + count(Depth) + count(Height) &gt; 0">
                    //DataSection/Resource/Size:
                        At least one of [Width,Depth,Height] must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/ResourceClass/Size">
            <sch:assert
                test="count(Width) + count(Depth) + count(Height) &gt; 0">
                    //DataSection/ResourceClass/Size:
                        At least one of [Width,Depth,Height] must be present
            </sch:assert>
        </sch:rule>
    </sch:pattern>

    <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/ContactInformation subtype usage rules">
        <sch:rule context="//DataSection/Order/CustomerParty">
            <sch:assert test="count(*) &gt; 0">
                //DataSection/Order/CustomerParty:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/Order/SupplierParty">
            <sch:assert test="count(*) &gt; 0">
                //DataSection/Order/SupplierParty:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/Job/RequestingParty">
            <sch:assert test="count(*) &gt; 0">
                //DataSection/Job/RequestingParty:
                    At least one child element must be present
```

```
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/Job/PerformingParty">
            <sch:assert test="count(*) &gt; 0">
                //DataSection/Job/PerformingParty:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/ContactParty usage rule">
        <sch:rule context="//DataSection//ContactParty">
            <sch:assert
            test="count(OrganizationName) + count(PersonName) &gt; 0">
            //DataSection//ContactParty:
                At least one of [PersonName,OrganizationName] must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/CostAllocationData usage rule">
        <sch:rule context="//DataSection//CostAllocationData">
            <sch:assert test="(CostType = 'variable' and
                                    count(VariableCostData) = 1) or
                                    count(VariableCostData) = 0">
                //DataSection//CostAllocationData:
                    If VariableCostData is present, CostType must be 'variable'
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="MachineProgramData usage rule">
        <sch:rule context="//DataSection//MachineProgramInformation">
            <sch:assert test="count(*) &gt; 0">
                //DataSection//MachineProgramInformation:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="Event usage rule">
        <sch:rule context="//DataSection//Event">
            <sch:assert test="count(*) &gt; 0">
                //DataSection//Event:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/ColorHighlight subtype usage rules">
        <sch:rule context="//DataSection/LayoutObject/Shape/BasicShape/Color">
```

```
            <sch:assert test="count(LineColor) +
                              count(FillColor) +
                              count(AlphaValue) &gt; 0">
            //Shape/BasicShape/Color:
            At least one of [LineColor,FillColor,AlphaValue] must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/LayoutObject/Shape/Segment/Color">
            <sch:assert test="count(LineColor) +
                              count(FillColor) +
                               count(AlphaValue) &gt; 0">
            //Shape/Segment/Color:
              At least one of [LineColor,FillColor,AlphaValue] must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/PartGroup subtype usage rules">
        <sch:rule context="//DataSection//PartsProduced">
            <sch:assert
                test="count(PartQuantity) + count(PartInstance) &gt; 0">
                //DataSection//PartsProduced:
                    At least one of [PartQuantity,PartInstance] must be present
            </sch:assert>
            <sch:assert    test="(count(PartQuantity) and
                                  count(PartType) = 1) or
                                  count(PartQuantity) = 0">
                //DataSection//PartsProduced:
                    If PartQuantity is present, PartType must also be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection//PartsConsumed">
            <sch:assert
                test="count(PartQuantity) + count(PartInstance) &gt; 0">
                //DataSection//PartsConsumed:
                    At least one of [PartQuantity,PartInstance] must be present
            </sch:assert>
            <sch:assert    test="(count(PartQuantity) and
                                  count(PartType) = 1) or
                                  count(PartQuantity) = 0">
                //DataSection//PartsConsumed:
                    If PartQuantity is present, PartType must also be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection//PartsUsed">
            <sch:assert test="count(PartQuantity) +
                                  count(PartInstance) &gt; 0">
            //DataSection//PartsUsed:
                At least one of [PartQuantity,PartInstance] must be present
            </sch:assert>
            <sch:assert    test="(count(PartQuantity) and
                                  count(PartType) = 1) or
                                  count(PartQuantity) = 0">
                //DataSection//PartsUsed:
                    If PartQuantity is present, PartType must also be present
```

```
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/LocationDefinition subtype usage rules">
        <sch:rule context="//DataSection/InventoryItem/Location">
            <sch:assert test="count(*) &gt; 0">
                //DataSection/InventoryItem/Location:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/Part/Location">
            <sch:assert test="count(*) &gt; 0">
                //DataSection/Part/Location:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BasicStructures/ResourcesRequired subtype usage rules">
        <sch:rule context="//DataSection//ResourcesRequired">
            <sch:assert test="count(*) &gt; 0">
                //DataSection//ResourcesRequired:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection//ResourcesUsed">
            <sch:assert test="count(*) &gt; 0">
                //DataSection//ResourcesUsed:
                    At least one child element must be present
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="HeaderSection usage rule">
        <sch:rule context="//CMSDDocument/HeaderSection">
            <sch:assert test="count(*) &gt; 0">
                The HeaderSection element may not be empty
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="DataSection uniqueness constraint rule">
        <sch:rule context="//CMSDDocument/DataSection/*">
            <assert test="count(
                        //DataSection/*[./Identifier = current()/Identifier
                                    and name(.) = name(current()) ]
                                ) = 1">
            <name path="self::*"/>[
                Identifier='<value-of select="self::*/Identifier"/>'
                ] is  not unique!
            </assert>
```

```
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="UnitDefaults">
        <sch:rule context="//CMSDDocument/HeaderSection/UnitDefaults">
                <sch:assert
                  test="count(*) &gt; 0">The UnitDefaults element may not be empty
                </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="ShapeDescription check">
        <sch:rule context="//DataSection/LayoutObject/Shape[BasicShape]">
                <sch:assert test="ShapeType = 'basic'">
                        If a BasicShape element is present in a
                                ShapeDescription element, the ShapeType must be 'basic'
                </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/LayoutObject/Shape[Graphic]">
                <sch:assert test="ShapeType = 'graphic'">
                        If a Graphic element is present in a
                                ShapeDescription element, the ShapeType must be 'graphic'
                </sch:assert>
        </sch:rule>
        <sch:rule context="//DataSection/LayoutObject/Shape[Segment]">
                <sch:assert test="ShapeType = 'segment'">
                        If a Segment element is present in a
                                ShapeDescription element, the ShapeType must be 'segment'
                </sch:assert>
        </sch:rule>
        <sch:rule
                context="//DataSection/LayoutObject/Shape[TextualAnnotation]">
                <sch:assert test="ShapeType = 'text'">
                        If a TextualAnnotation element is present in a
                                ShapeDescription element, the ShapeType must be 'text'
                </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="Rotation">
        <sch:rule context="//DataSection//Transformations/Rotation">
                <sch:assert test="count(*) &gt; 1">
                        The Rotation element must contain at least
                        one of the elements XDegree, YDegree, or ZDegree.
                </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="Translation">
        <sch:rule context="//DataSection//Transformations/Translation">
                <sch:assert test="count(*) &gt; 0">
                        The Translation element may not be empty.
```

```
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
         name="Scaling">
        <sch:rule context="//DataSection//Transformations/Scaling">
            <sch:assert test="count(*) &gt; 0">
                The Scaling element may not be empty.
            </sch:assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="CMSDDocument">
        <sch:rule
            context="//DataSection/LayoutObject/Shape/BasicShape
                    [Type = 'polygon']">
            <sch:assert test="count(Point) &gt; 2">
                A Polygon BasicShape must contain at least
         3 Point sub elements
            </sch:assert>
        </sch:rule>
</sch:pattern>



<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="PropertyDescription">
        <sch:rule context="//HeaderSection/Metadata/PropertyDescription">
            <assert
            test="count(PropertyDataTypeDescription
                    [PropertyDataType = 'stochastic' ]) &lt;= 1 and
                 count(PropertyDataTypeDescription
                    [PropertyDataType = 'simple' ]) &lt;= 1 and
                 count(PropertyDataTypeDescription
                    [PropertyDataType = 'reference' ]) &lt;= 1 ">
                A PropertyDescription element may not have more than one
                    PropertyDataTypeDescription elements with a
                    PropertyDataType value = '<value-of
                    select="PropertyDataTypeDescription/PropertyDataType"/>'!
            </assert>
        </sch:rule>
</sch:pattern>


<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="BillOfMaterialsComponent">
        <sch:rule
            context="//DataSection/BillOfMaterials/BillOfMaterialsComponent">
            <sch:assert test="count(PartType) + count(SubComponent) &gt; 0">
                The BillOfMaterialsComponent element must contain at
                    least one of the elements PartType and SubComponent
            </sch:assert>
        </sch:rule>
</sch:pattern>
```

```
<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
      name="InventoryItem">
      <sch:rule context="//DataSection/InventoryItem">
            <sch:assert test="not(AssociatedPart and AssociatedResource)">
            //DataSection/InventoryItem:
                  AssociatedPart and AssociatedResource must not appear together.
            </sch:assert>
            <sch:assert
                  test="QuantityOnHand or
                              (not(QuantityOnHand) and
                                    count(AssociatedPart) +
                                    count(AssociatedResource) &gt; 0)">
                  //DataSection/InventoryItem:
                        If QuantityOnHand is not present,
                        either AssociatedPart or AssociatedResource must be present.
            </sch:assert>
      </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
      name="JobEffortDescription subclasses">
      <sch:rule context="//DataSection/Job/ActualEffort">
            <sch:assert test="count(*) &gt; 0">
                  At least one child of ActualEffort must be present
            </sch:assert>
      </sch:rule>
      <sch:rule context="//DataSection/Job/PlannedEffort">
            <sch:assert test="count(*) &gt; 0">
                  At least one child of PlannedEffort must be     present
            </sch:assert>
      </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
      name="OrderLineServiceDescription">
      <sch:rule context="//DataSection/Order/OrderLine/ServiceDescription">
            <sch:assert test="count(*) &gt; 0">
                  The ServiceDescription element may not be empty
            </sch:assert>
      </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
      name="OrderLinePartDescription">
      <sch:rule context="//DataSection/Order/OrderLine/PartDescription">
            <sch:assert test="count(*) &gt; 0">
                  The PartDescription element may not be empty
            </sch:assert>
      </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
      name="ScheduleItem">
      <sch:rule context="//DataSection/Schedule/ScheduleItem">
            <sch:assert
```

```
                test="count(PlannedEffort) +count(ActualEffort) &gt; 0">
                    At least one of the elements PlannedEffort and ActualEffort
                        must be present
                </sch:assert>
            </sch:rule>
        </sch:pattern>

        <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
            name="Shift">
            <sch:rule context="//DataSection/Calendar/Shift">
                <sch:assert test="count(ApplicableDay) &lt; 8">
                    There should be no more than 7 ApplicableDay elements
                </sch:assert>
            </sch:rule>
        </sch:pattern>

        <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
            name="Resource.EmployeeSkill check">
            <sch:rule context="//DataSection/Resource[EmployeeSkill]">
                <sch:assert test="ResourceType = 'employee'">
                    If EmployeeSkill is present in a Resource element,
                        the ResourceType must be 'employee'
                </sch:assert>
            </sch:rule>
        </sch:pattern>

        <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
            name="Resource.CurrentSetup check">
            <sch:rule context="//DataSection/Resource[CurrentSetup]">
                <sch:assert test="ResourceType != 'employee'">
                    If an CurrentSetup element is present in a Resource element,
                        the ResourceType must not be 'employee'
                </sch:assert>
            </sch:rule>
        </sch:pattern>

        <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
            name="Connection">
            <sch:rule context="//DataSection/Resource/GroupDefinition/Connection">
                <sch:assert test="count(FromResource) + count(ToResource) &gt; 0">
                    The     Connection element must contain at least one of
                        the elements FromResource and ToResource
                </sch:assert>
            </sch:rule>
        </sch:pattern>

        <sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
            name="Calendar contents limited uniqueness constraint">
            <sch:rule context="//DataSection/Calendar/*[Identifier]">
                <assert
                    test="count(//DataSection/Calendar/*
                        [Identifier = current()/Identifier and
                        current()/../Identifier = ../Identifier ] ) = 1">

             <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/
```

```
            <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                                is  not unique!
                </assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="SkillLevel limited uniqueness constraint">
        <sch:rule context="//DataSection/SkillDefinition/SkillLevel">
                <assert
                        test="count(//SkillDefinition/SkillLevel
                                [Identifier = current()/Identifier and
                                        current()/../Identifier = ../Identifier ] ) = 1">

    <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/

            <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                                is  not unique!
                </assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="Connection limited uniqueness constraint">
        <sch:rule context="//DataSection/Resource/GroupDefinition/Connection">
                <assert
                        test="count(//DataSection/Resource/GroupDefinition/Connection
                                [Identifier = current()/Identifier and
                                current()/../../Identifier = ../../Identifier ] ) = 1">

    <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/

            <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                                is  not unique!
                </assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="Process limited uniqueness constraint">
        <sch:rule context="//DataSection/ProcessPlan/Process">
                <assert
                        test="count(//ProcessPlan/Process
                                [Identifier = current()/Identifier and
                                        current()/../Identifier = ../Identifier ] ) = 1">

    <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/

            <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                                is  not unique!
                </assert>
        </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
        name="MaintenanceProcess limited uniqueness constraint">
        <sch:rule context="//DataSection/MaintenancePlan/MaintenanceProcess">
                <assert
                        test="count(//DataSection/MaintenancePlan/MaintenanceProcess
```

```
                    [Identifier = current()/Identifier and
                    current()/../Identifier = ../Identifier ] ) = 1">
    <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/
        <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                    is  not unique!
        </assert>
    </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
    name="ScheduleItem limited uniqueness constraint">
    <sch:rule context="//DataSection/Schedule/ScheduleItem">
        <assert
            test="count(//DataSection/Schedule/ScheduleItem
                [Identifier = current()/Identifier and
                current()/../Identifier = ../Identifier ] ) = 1">
     <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/
        <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                    is  not unique!
        </assert>
    </sch:rule>
</sch:pattern>

<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
    name="OrderLine limited uniqueness constraint">
    <sch:rule context="//DataSection/Order/OrderLine">
        <assert
            test="count(//DataSection/Order/OrderLine
                [Identifier = current()/Identifier and
                    current()/../Identifier = ../Identifier ] ) = 1">
    <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/
        <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                    is  not unique!
        </assert>
    </sch:rule>
</sch:pattern>
<sch:pattern xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
    name="BillOfMaterialsComponent limited uniqueness constraint">
    <sch:rule
        context="//DataSection/BillOfMaterials/BillOfMaterialsComponent">
        <assert
            test="count(//BillOfMaterials/BillOfMaterialsComponent
            [Identifier = current()/Identifier and
            current()/../Identifier = ../Identifier ] ) = 1">
    <name path=".."/>[Identifier='<value-of select="../Identifier"/>']/
        <name path="self::*"/>[Identifier=' <value-of select="self::*/Identifier"/>']
                    is  not unique!
        </assert>
    </sch:rule>
```

```
    </sch:pattern>
</sch:schema>
```

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Annex B CMSDTools SourceForge Project (Informative)

A CMSDTools Sourceforge project was established during development of this standard to disseminate CMSD related information. The main project directory is found here:

http://sourceforge.net/projects/cmsdtools/

Within the project, directories containing the following information include:

- CMSDDotNet
  - Contains C# classes to create a .Net library that enables CMSD documents to be created, manipulated, and validated using objects defined based on the classes defined in the CMSD – UML specification
- CMSDJava
  - Contains Java classes to create a .Net library that enables CMSD documents to be created, manipulated, and validated using objects defined based on the classes defined in the CMSD – UML specification
- Resources
  - Contains:
    - RelaxNg and Schematron schemas that can be used to validate CMSD Documents, and
    - Example of both valid and invalid CMSD documents
- Tools
  - Contains scripts that allow Schematron information to be extracted from RelaxNG schemas and to be converted into XSL.