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0 Submission Introduction

0.1 Submission Overview

This document is the second of two documents submitted in response to the Systems Modeling Language (SysML®) v2 Request for Proposals (RFP) (ad/2017-11-04). The first document defines a Kernel Modeling Language (KerML) that provides a syntactic and semantic foundation for creating more specific modeling languages. This document provides the proposed specification of the actual Systems Modeling Language (SysML), version 2.0, built on this foundation.

Even though both documents are being submitted together to fulfill the requirements of the RFP, the document for KerML is being proposed as a separate specification from SysML v2. By intent, KerML provides a common kernel for the creation of diverse modeling languages that can be tailored to specific domains while still maintaining fundamental semantic interoperability. SysML v2 is such a modeling language, tailored to the systems modeling domain. It is the combination of the kernel provided by KerML and the systems-domain specific metamodel defined in this document that together satisfy the requirements of the SysML v2 RFP, as documented in subclause 0.4.

Release note. The present document is an update to the initial submission document submitted to OMG in August 2020.

0.2 Submission Submitters

The following OMG member organizations are jointly submitting this proposed specification:

- 88Solutions Corporation
- Dassault Systèmes
- GfSE e.V.
- IBM
- INCOSE
- InterCax LLC
- Lockheed Martin Corporation
- MITRE
- Model Driven Solutions, Inc.
- PTC
- Simula Research Laboratory AS
- Thematix

The submitters also thankfully acknowledge the support of over 60 other organizations that participated in the SysML v2 Submission Team.

0.3 Submission - Issues to be discussed

6.7.1 Proposals shall describe a proof of concept implementation that can successfully execute the test cases that are required in 6.5.4.

The SST is developing a pilot implementation of the full SysML abstract syntax and textual concrete syntax. There have been four quarterly public releases of this pilot implementation so far, the last being the 2020-06 version released at the beginning of July 2020. However, since the conformance test suite has not been developed as of the time of this initial submission, it is not possible to formally demonstrate the conformance of the implementation to the proposed specification. Nevertheless, the majority of this proposed specification describes the language as it has been implemented. For those specific areas in which the pilot implementation as of the 2020-06 release is known to not fully conform to the initial submission of the SysML specification, the deviations are identified in "implementation notes" in this document. The SST is currently planning on releasing the 2020-09 version of the

pilot implementation as open source, at which time it is intended that it will be fully conformant with the initial submission of this specification.

The SST has also been prototyping graphical visualization tools using the SysML graphical concrete syntax. However, these implementations are not yet as complete as the implementation of the textual notation.

6.7.2 Proposals shall provide a requirements traceability matrix that demonstrates how each requirement in the RFP is satisfied. It is recognized that the requirements will be evaluated in more detail as part of the submission process. Rationale should be included in the matrix to support any proposed changes to these requirements.

See subclause [0.4](#).

6.7.3 Proposals shall include a description of how OMG technologies are leveraged and what proposed changes to these technologies are needed to support the specification.

This specification is a replacement for the SysML v1.x series of standards (collectively referred to as "SysML v1"). SysML v1 was defined as a profile of the Unified Modeling Language [UML]. SysML v2, however, is defined with its own metamodel, which is build on the Kernel Metamodel [KerML]. As required in the SysML v2 RFP, the abstract syntax for SysML is defined as a model that is consistent with the OMG Meta Object Facility [MOF] as extended with MOF Support for Semantic Structures [SMOF]. (See also [KerML, 0.3] for further discussion of the relationship to MOF.)

The SysML v2 RFP also requires that a UML profile be provided for SysML v2 "that includes, as a minimum, the functional capabilities of the SysML v1.x profile, and a mapping to the SysML v2 metamodel" (RFP requirement LNG 1.1.3). The SysML v2 specification proposed in tihs initial submission includes a model of a transformation from SysML v1.7 (expected to be the last version of SysML v1) to SysML v2 (see [Annex C](#)). This transformation effectively allows the SysML v1.7 profile to also be used as a profile for the subset of SysML v2 functional capabilities that have equivalent capabilities in SysML v1, minimally meeting the RFP requirement.

Consideration is still being given to developing a more extensive SysML v2 profile for the revised submission, depending on the availability of resources and the desires of the SysML community of stakeholders.

0.4 Language Requirements Tables

0.4.1 Mandatory Language Requirements Table

Table 1. Mandatory Language Requirements Table

Req. ID	Req. Name	Text
ANL 1	Analysis Requirements Group	The requirements in this group are used to specify an analysis, along with other requirements such as Properties, Values, and Expressions.
ANL 1.01	Subject of the Analysis	Proposals for SysML v2 shall include the capability to model the relationship between the analysis and the subject of the analysis (system being analyzed).
ANL 1.02	Analysis	Proposals for SysML v2 shall include the capability to specify an Analysis, including the subject of analysis (e.g., system), the analysis case, and the analysis models and related infrastructure to perform the analysis.

Req. ID	Req. Name	Text
ANL 1.03	Parameters of Interest	Proposals for SysML v2 shall include the capability to identify the key parameters of interest including measures-of-effectiveness (MoE) and other key measures of performance (MoP).
ANL 1.04	Analysis Case	<p>Proposals for SysML v2 shall include the capability to model the analysis case to specify the analysis scenarios and associated analysis methods needed to produce an analysis result that achieves the analysis objectives.</p> <p>Supporting Information: This is intended to be a specialization of Case.</p>
ANL 1.05	Analysis Objectives	Proposals for SysML v2 shall include the capability to model the objective of the analysis being performed in text or as a mathematical formalism, e.g. math expression, so that it can be evaluated.
ANL 1.06	Analysis Scenarios	Proposals for SysML v2 shall include the capability to model the scenarios that identify the analysis models to be executed, the conditions and assumptions, and the configurations of the subject of the analysis and the related infrastructure to perform the analysis.
ANL 1.07	Analysis Assumption	Proposals for SysML v2 shall include the capability to model the assumptions of the analyses in a text or mathematical form, e.g. constraints and boundary conditions.
ANL 1.08	Analysis Decomposition	Proposals for SysML v2 shall include the capability to decompose an analysis into constituent analyses.
ANL 1.09	Analysis Model	<p>Proposals for SysML v2 shall include the capability to specify an analysis model.</p> <p>Supporting Information: Analysis models can be defined natively in SysML (e.g. parametric model or behavior model) or externally (e.g. equation-based math models, finite element analysis models, or computational fluid dynamics models). The level of fidelity of the specification of the analysis model can vary from an abstract specification that defines the intent of the analysis including its input and output parameters, to a detailed specification that a particular solver can execute.</p>
ANL 1.11	Analysis Result	<p>Proposals for SysML v2 shall include the capability to relate the results of executing analysis models to the analysis.</p> <p>Supporting Information: The results may be stored in the SysML v2 model itself or in an external store (e.g. CSV file or database). The results can be used to evaluate how well the analysis objectives are satisfied, and to obtain the supporting rationale for decisions taken based on the analysis.</p>

Req. ID	Req. Name	Text
ANL 1.13	Analysis Metadata	Proposals for SysML v2 shall include the capability to represent the metadata relevant to specifying the analysis, including the specification of dependent and independent parameters.
ANL 1.14	Decision Group	The requirements in this group support trade-off analysis among alternatives. This typically involves making decisions during the design process to evaluate alternative designs based on a set of criteria, and selecting a preferred design.
ANL 1.14.2	Alternative	Proposals for SysML v2 shall include a capability to represent a set of alternatives.
ANL 1.14.4	Decision	<p>Proposals for SysML v2 shall include a capability to represent a decision as one or more selections among alternatives.</p> <p>Supporting Information: This Decision and Rationale can be related through an Explanation relationship. The Rationale can refer to the supporting analysis.</p>
ANL 1.14.5	Criteria	Proposals for SysML v2 shall include a capability to represent criteria that is used as a basis for a decision or evaluation.
ANL 1.14.6	Rationale	Proposals for SysML v2 shall include a capability to represent rationale for a decision or other conclusion.
BHV 1	Behavior Requirements Group	
BHV 1.01	Behavior	Proposals for SysML v2 shall include the capability to model a Behavior that represents the interaction between individual structural elements and their change of state over time.

Req. ID	Req. Name	Text
BHV 1.02	Behavior Decomposition	<p>Proposals for SysML v2 shall include the capability to decompose a behavior to any level of decomposition, and to define localized usages of behavior at nested levels of decomposition.</p> <p>Supporting Information:</p> <p>The decomposition of behavior should conform to a similar pattern as the decomposition of structure, and include capabilities for specialization, redefinition, and sub-setting.</p> <p>The decomposition should also include the equivalent capability to decompose a SysML v1 activity on a BDD, and the ability to decompose actions using a structured activity node.</p>
BHV 1.03	Function-based Behavior Group	
BHV 1.03.1	Function-based Behavior	<p>Proposals for SysML v2 shall include the capability to represent a controlled sequence of actions (or functions) that can transform a set of input items to a set of output items.</p> <p>Supporting Information:</p> <p>SysML v2 should provide an integrated approach to specify behavior that reflects similar capabilities to SysML v1 activities and sequence diagrams, which are expected to be different views of the same underlying model.</p> <p>The input items and output items correspond to item usages and their associated value properties whose values can vary over time. Item flows connect an output item usage to an input item usage.</p> <p>The start and stop events should be represented explicitly (e.g., control pins). Event flows connect a stop event to a start event.</p> <p>The specific features of activities and sequence diagrams to be included in SysML v2 beyond what is specified in this section should be defined in the proposal.</p>
BHV 1.03.3	Function-based Behavior Constraints	<p>Proposals for SysML v2 shall include the capability to model constraints on a function-based behavior that includes the ability to represent a declarative specification in terms of its pre-conditions and post-conditions, and any constraints that apply throughout execution of the behavior.</p>
BHV 1.03.4	Opaque Behavior	<p>Proposals for SysML v2 shall include the capability to represent a behavior that embeds the definition in a language such as a programming language.</p>

Req. ID	Req. Name	Text
BHV 1.03.6	Structure Modification Behavior	<p>Proposals for SysML v2 shall include the capability to represent behaviors that can modify the structure of an element over time, such as the creation and destruction of interconnections and composition.</p> <p>Supporting Information:</p> <p>An example is the behavior associated with the separation of a first stage rocket, or the assembly or disassembly of a product.</p>
BHV 1.04	State-based Behavior Group	
BHV 1.04.1	Regions, States, and Transitions	<p>Proposals for SysML v2 shall include the capability to represent the state behavior of a structural element in terms of its concurrent regions with mutually exclusive finite states, and transitions between finite states.</p> <p>Supporting Information:</p> <p>A state change can result from a change in structure.</p>
BHV 1.04.2	Integration of Function-based Behavior with Finite State Behavior	<p>Proposals for SysML v2 shall include the capability to model function-based behavior both on transitions between finite states, and upon entry, exit, and while in a finite state.</p>
BHV 1.04.3	Integration of Constraints with Finite State Behavior	<p>Proposals for SysML v2 shall include the capability to model constraints both on transitions between finite states, and upon entry, exit, and while in a finite state.</p>
BHV 1.05	Discrete and Continuous Time Behavior	<p>Proposals for SysML v2 shall include the capability to model behaviors whose inputs and outputs vary continuously as a function of time, or discretely as a function of time.</p>
BHV 1.06	Events	<p>Proposals for SysML v2 shall include the capability to model signal events, time events, and change events and their ordering.</p> <p>Supporting Information:</p> <p>The ordering of actions (i.e., functions) is accomplished through ordering of their start and completion events.</p> <p>Events can trigger a change from one finite-state to another.</p> <p>Events should be able to be explicitly represented in both function-based behavior and finite-state behavior.</p> <p>Events can be defined and used in different contexts.</p>

Req. ID	Req. Name	Text
BHV 1.07	Control Nodes	<p>Proposals for SysML v2 shall include the capability to model control nodes that specify a logical expression of conditions and events to enable a flow.</p> <p>Supporting Information: For Example: {Inputs A < a1 AND B>=b2 OR C AND NOT D} must be true).</p>
BHV 1.08	Time Constraints	<p>Proposals for SysML v2 shall include the capability to specify the absolute or relative time associated with an event that includes start events, stop events, and duration constraints between events to represent the time-line associated with a behavior.</p> <p>Supporting Information: Time is a property typed by a Value Type whose quantity kind and units are specified as part of QUDV.</p>
BHV 1.10	Behavior Execution	<p>Proposals for SysML v2 shall include the capability to execute function-based and state-based behavior to specify the state history of individual elements and their interactions with other individual elements.</p> <p>Supporting Information: The behavior of a Definition Element or Configuration Element represent the default behavior of the conforming Individual Elements.</p>
BHV 1.11	Integration between Structure and Behavior	
BHV 1.11.1	Allocation of Behavior to Structure	<p>Proposals for SysML v2 shall include the capability to represent the behavior of one or more structural elements.</p> <p>Supporting Information:</p> <p>This should support the ability to define a state machine of a structural element, with finite states that enable actions (i.e., functions) and constraints. In addition, this should support the ability to specify the functions performed by a component, and the applicable constraints, without specifying the finite state that enables them. The representation should allow more than one structural element to perform a single function, such as when two people carry a load. This is analogous to a reference interaction in a SysML v1 sequence diagram that spans multiple lifelines and displays the participating lifelines. The reference interaction refers to another sequence diagram.</p>

Req. ID	Req. Name	Text
BHV 1.11.2	Integration of Control Flow and Input/Output Flow	<p>Proposals for SysML v2 shall ensure that inputs, outputs, and events can be represented consistently across behavior and structure.</p> <p>Supporting Information:</p> <p>In SysML v1, it is often difficult to ensure consistent representation of control flow and input/output flow. Examples include potential inconsistencies between:</p> <ul style="list-style-type: none"> • Flows on activity diagrams and messages on sequence diagrams. • Flows on activity diagrams and item flows on ibd • Inputs and outputs on activity diagram and corresponding inputs and outputs on activity decomposition on a bdd • Inability to represent input/output of activities on do behaviors of state machines
BHV 1.11.3	Storing Items in Storage Elements Requirements Group	
BHV 1.11.3.1	Storage Element and Stored Item Usages	<p>Proposals for SysML v2 shall include the capability to model a storage element that can store items declared by stored item usages. The stored items shall be identified as conserved (e.g., a physical element) or copied (e.g., data from memory). Conservation constraints shall apply to conserved item usages (e.g., amount in - amount out=amount stored).</p> <p>Supporting Information: Examples include:</p> <p>A storage element called tank that stores a stored item usage called fluid. (example of a conserved stored item usage)</p> <p>A storage element called common value table that stores a stored item usage called system mode. (example of a copied stored item usage)</p>

Req. ID	Req. Name	Text
BHV 1.11.3.2	Create, Modify, and Consume Stored Items	<p>Proposals for SysML v2 shall include the capability to model outputs and inputs of a behavior that create, modify, or consume stored items of a storage element. An input to or output from a storage element that results in the creation, modification, or consumption of stored items can be assigned to one or more ports of the storage element.</p> <p>Supporting Information: Examples include:</p> <p>A pump fluid action produces an output called fluid that is stored in a tank, and another action consumes the fluid from the tank. (example of a conserved stored item usage)</p> <p>An update mode variable action produces a logical data item that is stored in common value table, and another action called verify mode consumes the logical data item from the common value table. (example of a copied stored item usage)</p>
BHV 1.12	Case	<p>Proposals for SysML v2 shall include the capability to represent a case that can be specialized into a use case, verification case, analysis case, and domain specific cases, such as safety case and assurance case.</p> <p>Supporting Information: A case is a series of steps with an associated objective that produce a result or conclusion. An analysis case and assurance case correspond to a set of steps to implement a study or investigation. Refer to the Structured Assurance Case Metamodel (SACM).</p>
CNF 1	Conformance Requirements Group	<p>These requirements specify that the proposals provide a suite of test cases that a conformant SysML v2 implementation must satisfy. The test cases can more generally be verification cases.</p> <p>The SysML v2 specification will specify the conformance levels for each conformance area below. Vendors are expected to identify specific levels of conformance within each of the sub-section of groupings in this document so that a cross functional compliance matrix can be developed for each tool implementation. This enables the ecosystem of potential SysML tool vendors who only wish to partially implement the SysML specification to expand, (i.e. only the requirements or test aspects for example).</p>
CNF 1.1	Metamodel Conformance	Proposals for SysML v2 shall provide test cases to assess conformance of a SysML v2 implementation with the SysML v2 metamodel specification (abstract syntax, concrete syntax, and semantics).
CNF 1.2	Profile Conformance	Proposals for SysML v2 shall provide test cases to assess conformance of a SysML v2 implementation with the SysML v2 profile specification.

Req. ID	Req. Name	Text
CNF 1.3	Model Interoperability Conformance	Proposals for SysML v2 shall provide test cases to assess conformance of a SysML v2 implementation with the SysML v2 model interoperability specification.
CNF 1.4	Traceability Matrix	Proposals for SysML v2 shall include a traceability matrix (include reference) that demonstrates how each language feature is verified by the conformance test suite.
CRC 1	Cross-cutting Requirements Group	The following specify the requirements that apply to all model elements.
CRC 1.1	Model and Model Library Group	
CRC 1.1.1	Model	<p>Proposals for SysML v2 shall include a capability to represent a Model (aka system model) that contains a set of uniquely identifiable model elements.</p> <p>Supporting Information: This is intended to be a kind of Container or Namespace.</p>
CRC 1.1.2	Model Library	<p>Proposals for SysML v2 shall include a capability to represent a Model Library that contains a set of model elements that are intended to support reuse.</p> <p>Supporting Information: This is intended to be a kind of Container or Namespace.</p>
CRC 1.1.3	Container	<p>Proposals for SysML v2 shall include the capability to represent a Container that is a model element that contains other model elements. Model elements within a container shall be distinguishable from one another.</p> <p>Supporting Information: This provides a way to organize the model. Containers can contain other containers.</p>
CRC 1.2	Model Element Group	
CRC 1.2.2	Unique Identifier	<p>Proposals for SysML v2 shall include a capability to represent a single universally unique identifier for each model element that cannot be changed.</p> <p>Supporting Information: The unique identifier should enable assignment of URIs.</p>

Req. ID	Req. Name	Text
CRC 1.2.3	Name and Aliases	<p>Proposals for SysML v2 shall include a capability to represent a name and one or more aliases for any named model element.</p> <p>Supporting Information:</p> <p>Selected kinds of model elements may not require a name (e.g. dependency), or the name may be optional, but still should be distinguishable within a namespace.</p> <p>Aliases enable users to assign more than one name for the same element, such as a shortened name. A common use of aliases is the use of an abbreviated or shortened name.</p>
CRC 1.2.4	Definition / Description	<p>Proposals for SysML v2 shall include a capability to represent one or more definitions and/or descriptions for each model element.</p>
CRC 1.2.5	Annotation	<p>Proposals for SysML v2 shall include a capability to represent an annotation of one or more model elements that includes a text string. The text string can include a link that refers to a Navigation relationship (refer to CRC 1.3.10), and a classification field to identify the kind of annotation.</p> <p>Supporting Information: Annotations should be able to be related to other elements.</p>
CRC 1.2.6	Element Group	<p>Proposals for SysML v2 shall include a capability to represent a group of model elements that can satisfy user-defined criteria for membership in the group.</p> <p>Supporting Information:</p> <ol style="list-style-type: none"> 1. A member of an element group is not intended to impose ownership constraints on the members. 2. Element group can be specialized for different kinds of members, such as groups that contain requirements, functions, and structural elements, which may impose additional constraints on its members. 3. It shall be possible to define a relationship with an element group that is equivalent to defining the relationship with each member of the group.
CRC 1.2.7	Additional Cross-Cutting Concepts Group	<p>The requirements in this group include additional concepts that can be associated with any model element.</p>

Req. ID	Req. Name	Text
CRC 1.2.7.1	Problem	<p>Proposals for SysML v2 shall include a capability to represent a problem that causes an undesired affect.</p> <p>Supporting Information: A problem is often represented as a cause in a cause-effect relationship.</p>
CRC 1.2.7.2	Risk	<p>Proposals for SysML v2 shall include a capability to represent a Risk that identifies the kind of risk (e.g., cost, schedule, technical), and the likelihood of occurrence, and the potential impact.</p>
CRC 1.3	Model Element Relationships Requirements Group	
CRC 1.3.01	Relationship	<p>Proposals for SysML v2 shall include a capability to represent a Relationship between any two model elements, which may have a name and direction.</p>
CRC 1.3.02	Derived Relationship	<p>Proposals for SysML v2 shall include a capability to represent a relationship that is derived from other relationships.</p> <p>Supporting Information:</p> <p>An example is a derived relationship from a transitive relationship where B relates to A and C relates to B, then C relates to A.</p> <p>Another example is a connector between two composite parts that is derived from a connector between their nested parts.</p>
CRC 1.3.03	Dependency Relationship	<p>Proposals for SysML v2 shall include a capability to represent a Dependency Relationship where one side of the relationship refers to the independent element and the other side of the relationship refers to the dependent element.</p>
CRC 1.3.04	Cause-Effect Relationship	<p>Proposals for SysML v2 shall include a capability to represent a Cause-Effect Relationship where one side of the relationship refers to the cause and the other side of the relationship refers to the effect.</p>
CRC 1.3.05	Explanation Relationship	<p>Proposals for SysML v2 shall include a capability to represent an Explanation Relationship where one side of the relationship refers to the rationale and the other side of the relationship refers to the element being explained.</p>

Req. ID	Req. Name	Text
CRC 1.3.06	Conform Relationship	Proposals for SysML v2 shall include a capability to represent a Conform Relationship where the conforming element is constrained by the element on the other side of the relationship.
CRC 1.3.07	Refine Relationship	Proposals for SysML v2 shall include a capability to represent a Refine Relationship where the refined side of the relationships refers to the more precisely specified element.
CRC 1.3.08	Allocation Relationship	Proposals for SysML v2 shall include a capability to represent an Allocation Relationship where one side of the relationship refers to the allocated from, and the other side of the relationship refers to the allocated to.
CRC 1.3.09	Element Group Relationship	Proposals for SysML v2 shall include a capability to represent an Element Group Relationship where one side of the relationship refers to the member, and the other side of the relationship refers to the Element Group.
CRC 1.3.10	Navigation Relationship	<p>Proposals for SysML v2 shall include a capability to represent a Navigation Relationship between a model element and another model element or an external element, similar to a hyperlink, where one side of the relationship refers to the linked to, and the other side of the relationship refers to the linked from. The external element can be a data element, a file, and/or an element of an external model.</p> <p>Supporting information:</p> <p>This is a navigation aid that standardizes what many tools already do.</p> <p>The navigation can specify the ability to navigate from either end of the relationship.</p>
CRC 1.4	Variability Modeling Group	<p>The requirements in this group should accommodate approaches to model variants as choices among design options. The modeling approaches may include a separate variability model to identify the design choices. Additional variability modeling concepts may be included.</p> <p>Supporting Information: refer to ISO/IEC 26550:2015</p>
CRC 1.4.1	Variation Point	Proposals for SysML v2 shall include a capability to model variation points that identify features that can vary across a set of variants (e.g., vehicles with manual or automatic transmission, variable number of axles, or variable wheel size). A variation point may be dependent on another variant selection. (e.g., number of axles and wheel size is dependent on selection of load size).
CRC 1.4.2	Variant	Proposals for SysML v2 shall include a capability to model variants that correspond to particular selections that are associated with a variation point.

Req. ID	Req. Name	Text
CRC 1.4.3	Variability Expression and Constraints	Proposals for SysML v2 shall include a capability to model variability expressions that constrain possible variant choices (e.g., 3 axles plus large wheel size or 2 axles plus small wheel size).
CRC 1.4.4	Variant Binding	<p>Proposals for SysML v2 shall include a capability to model the binding between a variant and the model elements that vary.</p> <p>Supporting Information: The binding is intended to enable the use of a separate variability model that defines variation that may span multiple kinds of models such as a SysML model, simulation model, and a CAD model.</p>
CRC 1.5	View and Viewpoint Group	The following specify the requirements associated with View and Viewpoint.
CRC 1.5.1	View Definition	<p>Proposals for SysML v2 shall include a capability to define a class of artifacts that can be presented to a stakeholder.</p> <p>Supporting Information: The View Definition for a document can be thought of as its table of contents along with the list of figures and tables. The View Definition can be specialized, and decomposed into sub-views that can be ordered. An individual View is intended to be a specific artifact, such as a document, diagram, or table that is presented to a stakeholder. The individual View conforms to a View Definition that defines construction methods to create an individual View. The execution of the construction methods involves querying a particular model (or more generally one or more data sources) to select the kinds of model elements, and then presenting the information in a specified format.</p>
CRC 1.5.2	Viewpoint	<p>Proposals for SysML v2 shall include a capability to represent a Viewpoint that frames a set of stakeholders and their concerns. It specifies the requirements a View must satisfy.</p> <p>Supporting Information:</p> <p>The stakeholder and their concerns should be represented in the model.</p> <p>The concern represents aspects of the domain of interest that the stakeholder has an interest in.</p> <p>The intent is to align the view and viewpoint concepts with the update to ISO 42010.</p>

Req. ID	Req. Name	Text
CRC 1.6	Metadata Group	The requirements in this group identify metadata is a kind of model element that can apply to other model elements or to other elements external to the model that refer to a model element (e.g., a model configuration item). Also, refer to the requirement for Analysis Metadata in the Analysis requirements section.
CRC 1.6.1	Version	Proposals for SysML v2 shall include a capability to represent the version of one or more model elements, or of an element external to the model that refers to one or more model elements.
CRC 1.6.2	Time Stamp	Proposals for SysML v2 shall include a capability to represent a model management time stamp for one or more elements, or of another element that refers to one or more model elements.
CRC 1.6.3	Data Protection Controls	<p>Proposals for SysML v2 shall include a capability to represent Data Protection Controls for one or more model elements, or of another element that refers to one or more elements.</p> <p>Supporting Information: This can include markings such as ITAR, proprietary or security classifications</p>
INF 1	Interface Requirements Group	<p>SysML v2 is intended to provide a robust capability to model interfaces that constrain the physical and functional interaction between structural elements. An interface in SysML v2 includes two (2) interface ends, the connection between them, and any constraints on the interaction.</p> <p>Supporting Information:</p> <p>An interface should support the following:</p> <ol style="list-style-type: none"> 1. Different levels of abstraction that include logical, functional, and physical interfaces, nested interfaces, and interface layers; 2. Diverse domains that include a combination of electrical, mechanical, software, and user interfaces; 3. Reuse of interfaces in different contexts; 4. Generation of interface control documents and interface specifications <p>A Port is also used to refer to an Interface End.</p>

Req. ID	Req. Name	Text
INF 1.01	Interface Definition and Reuse	<p>Proposals for SysML v2 shall provide the capability to define an interface that can be used in different contexts that includes the definition of the interface ends, the interface connections, and the constraints on the interaction.</p> <p>Supporting Information:</p> <p>Interfaces must conform to the structural concepts of definition and usage. The constraints can constraint properties, such as conservation laws that can apply to a physical interface, and/or constraints on exchanged items such as protocol constraints that can apply to message exchange, and/or geometric constraints that can apply to a physical interface such as between a plug and socket.</p>
INF 1.02	Interface Usage	<p>Proposals for SysML v2 shall provide the capability to represent a usage of an interface that constrains the interaction between any two (2) structural elements.</p>
INF 1.03	Interface Decomposition	<p>Proposals for SysML v2 shall provide the capability to represent nested interfaces, such as when modeling two electrical connectors with pin to pin connections.</p>
INF 1.04	Interface End Definitions	<p>Proposals for SysML v2 shall provide the capability to represent the definition of an Interface End whose features constrain the interaction of the end, including items that can be exchanged and their direction, behavioral features, and constraints on properties.</p> <p>Supporting Information:</p> <p>Interface End Definitions are also referred to as Port Definitions and Interface End Usages are referred to as Port Usages or Ports for short.</p>
INF 1.05	Conjugate Interface Ends	<p>Proposals for SysML v2 shall provide the capability to reverse the direction of the items that are exchanged in an Interface End.</p>

Req. ID	Req. Name	Text
INF 1.06	Item Definition	<p>Proposals for SysML v2 shall provide the capability to represent the kind of items that can be exchanged between Interface Ends.</p> <p>Supporting Information: The items represent the type of things that are exchanged, such as water or electrical signals. The items may have physical characteristics such as mass, energy, charge, and force, and logical characteristics such as information that is encoded in the physical exchange. In addition to being exchanged, these items may also be stored.</p> <p>An item that is input to a component should become a stored item usage that can be transformed by function usages. An item, such as an engine that is an input and output of an assembly process, may also have the role as a component, when it is assembled into a vehicle. Item Definitions must conform to the structural concepts of definition and usage. The rate at which a usage of an Item Definition is updated may be marked with an update rate that is continuous or discrete valued. (Refer to Behavior Requirement called "Discrete and Continuous Time Behavior")</p>
INF 1.07	Interface Agreement Group	
INF 1.07.1	Item Exchange Constraints	<p>Proposals for SysML v2 shall provide the capability to constrain the interaction between the interface ends that includes constraints on the items to be exchanged, the allowable sequences and directions of those items, timing of the exchange and other characteristics. The items exchanged shall be consistent with the type and direction of the items specified in the connected Interface Ends.</p>
INF 1.07.2	Property Constraints	<p>Proposals for SysML v2 shall provide the capability to constrain the interaction between the interface ends that include mathematical constraints on the properties exposed by the Interface Ends.</p> <p>Supporting Information: The value properties may further be identified as Across or Through variables consistent with standard usage of the terms (e.g. specify properties that are constrained by conservation laws).</p>

Req. ID	Req. Name	Text
INF 1.08	Interface Medium	<p>Proposals for SysML v2 shall include a capability to represent an Interface Medium that enable 2 or more components to interact.</p> <p>Supporting Information: The Interface Medium may represent either an abstract or physical element that connects elements to enable interactions. Examples of an interface medium included an electrical harness, a communications network, a fluid pipe, the atmosphere, or even empty space. The interface medium may connect one to many components, which include support for peer-to-peer, multi-cast, and broadcast communications.</p> <p>Consider replacing the term Interface Medium with Transport Medium.</p>
INF 1.09	Interface Layers	<p>Proposals for SysML v2 shall provide the capability to represent interfaces between layers of an interface stack.</p> <p>Supporting Information:</p> <p>A layer of a stack can be represented as a component. A layer in a stack transforms the data to match the input to the adjacent layer. For example, an application layer may correspond to a component that transforms packets to match the TCP layer, and the TCP layer may correspond to a component that transforms the data to match the IP layer.</p>
INF 1.10	Allocating Functional Exchange to Interfaces	<p>Proposals for SysML v2 shall provide the capability to allocate or bind the outputs and inputs of a function to interface ends (or nested interface ends).</p> <p>Supporting Information:</p> <p>It is expected that there are validation rules to ensure consistency between the inputs and outputs of a function and the interface ends.</p> <p>This allocate or binding should be inherited by the Component subclasses.</p>
LNG 1	Language Architecture and Formalism Requirements Group	<p>This group specifies how the language is structured and defined.</p> <p>Supporting Information: Some concepts may be implemented as user-level model libraries.</p>
LNG 1.1	Metamodel and Profile Group	

Req. ID	Req. Name	Text
LNG 1.1.1	SysML Profile	<p>Proposals for SysML v2 shall be specified as a SysML v2 profile of UML that includes, as a minimum, the functional capabilities of the SysML v1.x profile, and a mapping to the SysML v2 metamodel.</p> <p>Supporting Information: Equivalent functional capability can be demonstrated by mapping the UML metaclasses and SysML stereotypes between SysML v2 and SysML v1.</p>
LNG 1.1.2	SysML Metamodel	<p>Proposals for SysML v2 shall be specified using a metamodel that includes abstract syntax, concrete syntax, semantics, and the relationships between them.</p>
LNG 1.1.3	Metamodel Specification	<p>Proposals for the SysML v2 metamodel shall be specified in MOF or SMOF.</p> <p>Supporting Information: MOF is a subset of SMOF. SMOF provides support for the Metamodel Extension Facility (MEF).</p>
LNG 1.3	Abstract Syntax Group	
LNG 1.3.1	Syntax Specification	<p>Proposals for SysML v2 abstract and concrete syntax shall be specified using MOF or SMOF (including constraints on syntactic structure).</p> <p>Supporting Information:</p> <p>Expressing the syntax formally using a single consistent language which is more understandable to the user.</p>
LNG 1.3.2	View Independent Abstract Syntax	<p>Proposals for the SysML v2 abstract syntax representation of SysML v2 models shall be independent of all views of the models.</p> <p>Supporting Information: Rationale</p> <p>This is intended to define the concept independent of how it is presented. This enables a consistent representation of concepts with common semantics across a diverse range of views, including graphical, tabular, and other textual representations.</p>
LNG 1.4	Concrete Syntax Group	

Req. ID	Req. Name	Text
LNG 1.4.1	Concrete Syntax to Abstract Syntax Mapping	<p>Proposals for the SysML v2 concrete syntax representation of all views of a SysML model shall be separate from, and mapped to the abstract syntax representation of that model. The concrete syntax representation can include one or more images or snippets of images.</p> <p>Supporting Information:</p> <p>Enables views to provide unambiguous concrete representation of the abstract syntax of the model.</p> <p>Enables views to be rendered in a consistent way across tools.</p>
LNG 1.4.2	Graphical Concrete Syntax	Proposals for SysML v2 shall provide a standard graphical concrete syntax.
LNG 1.4.3	Syntax Examples	<p>All examples of model views in the proposals for the SysML v2 specification shall include the concrete syntax of the view, and the mapping to the abstract syntax representation of the parts of the models being viewed.</p> <p>Supporting Information:</p> <p>Experience has shown that the mapping of examples to the concrete and abstract syntax is not always obvious. Making these mappings explicit helps clarify their formal specification.</p>
LNG 1.5	Extensibility Group	
LNG 1.5.1	Extension Mechanisms	<p>Proposals for SysML v2 syntax and semantics shall include mechanisms to subset and extend the language.</p> <p>Supporting Information: This is essential to enable further customization of the language. SysML v1 includes a stereotype and profile mechanism to extend the language.</p>
LNG 1.6	Model Interchange, Mapping, and Transformations Group	
LNG 1.6.3	UML Interoperability	Proposals for SysML v2 shall provide the capability to map shared concepts between SysML and UML.

Req. ID	Req. Name	Text
OTR 1	Interoperability Requirements Group	Other requirements from other topic areas that also relate to interoperability include API 01, LNG 1.6, and the Interoperability Services Group, SVC 6.
OTR 2	Usability Group	<p>An objective for SysML v2 is to address SysML v1 usability issues, and enable systems engineers and others to perform MBSE more effectively. The following usability goals apply to a diverse class of SysML v2 users:</p> <ol style="list-style-type: none"> 1. User understanding when creating or interpreting models 2. User engagement when creating or interpreting models (this particularly applies to consumers of the model data) 3. User productivity when creating models across the lifecycle
OTR 2.1	Usability Evaluation	<p>The SysML v2 submission shall demonstrate how the SysML v2 specification satisfies the following usability criteria to meet the usability goals for the different classes of users and goals.</p> <p>To be provided</p>
PRP 1	Properties, Values and Expressions Requirements Group	The requirements in this group provide a unified representation of the type of properties, variables, constants, operation parameters and return types as well as literal values and value expressions. This includes types to represent variable size collections, compound value types, and measurement units and scales.
PRP 1.01	Unified Representation of Values	<p>Proposals for SysML v2 shall include a capability to represent any value-based characteristic in a unified way, called a value property, which shall include representation of a constant, a variable in an expression or a constraint, state variable, as well as any formal parameter and the return type of an operation.</p> <p>Supporting Information:</p> <p>A classification of "invariant" can be attached to a value property to assert that is does not vary over time. A constant is an invariant value property of some higher-level context (ultimately the "universe" in case of fundamental physics constants).</p> <p>Provisions should be made to distinguish between a fundamental physical or mathematical constant (i.e., Pi) from a constant value within the context of a particular model or model execution (i.e., amplifier gain).</p>
PRP 1.02	Value Type	Proposals for SysML v2 shall include a capability to represent a Value Type as a named definition of the essential semantics and structure of the set of allowable values of a value-based characteristic.

Req. ID	Req. Name	Text
PRP 1.03	Value Expression	Proposals for SysML v2 shall include a capability to represent a value as a literal or through a reusable Value Expression that is stated in an expression language. A Value Expression shall include the capability to represent opaque expressions.
PRP 1.05	Unification of Expression and Constraint Definition	Proposals for SysML v2 shall include a capability to represent a reusable constraint definition in the form of an equality or inequality of value expressions which can be evaluated to true or false.
PRP 1.06	System of Quantities	<p>Proposals for SysML v2 shall include a capability to represent a named system of quantities that support definition of numerical Value Types in accordance with the ISO/IEC 80000 standard.</p> <p>Supporting Information: The typical Systems of Quantities is the ISO/IEC 80000 International System of Quantities (ISQ) with seven base quantities: length, mass, time, electric current, thermodynamic temperature, amount of substance and luminous intensity.</p>
PRP 1.07	System of Units and Scales	<p>Proposals for SysML v2 shall include a capability to represent a named system of measurement units and scales to define the precise semantics of numerical Value Types in accordance with the [ISO/IEC 80000] standard.</p> <p>Supporting Information: Similar to SysML v1 QUDV, SysML v2 should include model libraries representing the [ISO/IEC 80000] units, as well as the conversion to US Customary Units defined in [NIST SP 811] Appendix B.</p>
PRP 1.08	Range Restriction for Numerical Values	<p>Proposals for SysML v2 shall include a capability to represent a value range restriction for any numerical Value Type.</p> <p>Supporting Information: This requirement allows further restriction of the range of values beyond what is specified by its type. A simple example is a planar angle typed by a real number Value Type and a degree measurement scale. However, the value range may be further restricted from 0 to 360 degrees for positioning a rotational knob. This can also include the definition of optional lower and upper bounds on an associated measurement scale.</p>
PRP 1.10	Primitive Data Types	<p>Proposals for SysML v2 shall include a capability to represent the following primitive data types as a minimum: signed and unsigned integer, signed and unsigned real, string, Boolean, enumeration type, ISO 8601 date and time, and complex.</p> <p>Supporting Information: These are intended to be represented in a Value Type Library as they are in SysML v1.</p>

Req. ID	Req. Name	Text
PRP 1.11	Variable Length Collection Value Types	Proposals for SysML v2 shall include a capability to represent variable length value collections where each member of the collection is typed by a particular Value Type and is referable by index, and where the collection may be one of the established collection types: sequence (ordered, non-unique), set (unordered, unique), ordered set (ordered, unique) or bag (unordered, non-unique).
PRP 1.12	Compound Value Type	<p>Proposals for SysML v2 shall include a capability to represent both scalar and compound Value Types, where a scalar Value Type represents elements with a single value, and compound Value Type represents elements with a fixed number of component values, where each component value is typed in turn by a scalar Value Type or another compound Value Type.</p> <p>Supporting Information: Such compound Value Types are needed to support the representation of vector, matrix, higher order tensor, complex number, quaternion, and other richer Value Types.</p>
PRP 1.15	Probabilistic Value Distributions	Proposals for SysML v2 shall include a capability to represent the value of a quantity with a probabilistic value distribution, including an extensible mechanism to detail the kind of distribution, i.e. the probability density function for continuous random variables, or the probability mass function for discrete random variables.
PRP 1.19	Materials with Properties	<p><html></p> <p>Proposals for SysML v2 shall include a capability to represent named materials with their material properties in a model library and assignment of such materials to physical elements such as hardware components.</p> <p>Supporting information: This requirement is intended to specify a model library with a generic material kind that has generic material properties that can be further specialized. Examples of generic material properties include density, hardness, and tensile yield strength.</p>
RML 1	Example Model and Model Libraries Group	
RML 1.1	Example Model	Proposals for SysML v2 shall include an example model that demonstrates the application of the SysML v2 language concepts to a commonly understood domain.
RQT 1	Requirement Group	The requirements in this group are used to represent requirements and their relationships.

Req. ID	Req. Name	Text
RQT 1.1	Requirement Definition Group	
RQT 1.1.1	Requirement Definition Name	Proposals for SysML v2 shall include a capability to represent a requirement definition that can be used to constrain a solution.
RQT 1.1.2	Requirement Identifier	Proposals for SysML v2 shall include a capability to represent an identifier for each requirement that is adaptable to a user defined numbering scheme, and can be set to not change.
RQT 1.1.3	Requirement Attributes	<p>Proposals for SysML v2 shall include a capability to represent the following optional requirement attributes for a requirement definition.</p> <ul style="list-style-type: none"> • Requirement Status • Priority • Risk • Originator/Author • Owner • User-defined Attributes (e.g., confidence level, uncertainty status, etc.) <p>Supporting Information: These attributes are derived from commonly used attributes as defined in the INCOSE Handbook and ReqIF, and should be reconciled with other model element metadata and model element attributes that apply more generally.</p>
RQT 1.1.4	Textual Requirement Statement	Proposals for SysML v2 shall include a capability to represent a requirement definition that contains an optional textual requirement statement.
RQT 1.1.5	Restricted Requirement Statement Group	<p><html></p> <p>Supporting Information: Refer to Restricted Use Case Modeling (RUCM) [36] as an example of a restricted requirement statement.</p>
RQT 1.1.5.1	Restricted Requirement Statement	Proposals for SysML v2 shall include a capability to represent a requirement definition that contains an optional restricted requirement statement which may include predefined key words and sentence structures.
RQT 1.1.5.2	Restricted Requirement Statement Extensibility	Proposals for SysML v2 shall include a capability to extend a restricted requirement statement with additional key words and sentence structures.

Req. ID	Req. Name	Text
RQT 1.1.5.3	Restricted Requirement Statement Transformation	SysML v2 will include a capability to maintain traceability between the restricted requirement statement and the textual requirement statement and/or the formal requirement statement.
RQT 1.1.6	Formal Requirement Statement Group	
RQT 1.1.6.1	Formal Requirement Statement	<p>Proposals for SysML v2 shall include a capability to represent a requirement definition that contains an optional formal requirement statement that includes one or more constraints that an acceptable solution must satisfy.</p> <p>Supporting Information: It is desired to also enable the element that is intended to satisfy the requirement to contain the formal requirement statement. This can provide a more lightweight modeling style.</p>
RQT 1.1.6.2	Assumptions	<p>Proposals for SysML v2 shall include a capability to represent a formal requirement statement that includes one or more expressions to specify the assumptions and conditions for acceptable solutions (e.g., the weight of a car includes the fuel weight)</p> <p>Supporting Information: This should be consistent with the concept of Assumption that is applied in other parts of the model.</p>
RQT 1.2	Groups of Requirements	
RQT 1.2.1	Requirement Group	<p>Proposals for SysML v2 shall provide the capability to model a group of requirements that are used to constrain a solution.</p> <p>Supporting Information: This is intended to be a sub-class of Element Group.</p>
RQT 1.2.2	Requirement Usage (localized)	<p>Proposals for SysML v2 shall include a capability to represent localized values of a requirement usage that can over-ride the values of its requirement definition.</p> <p>Supporting Information: The structural concepts of definition, usage, configuration, and individuals are intended to support reuse of requirement definitions, and unambiguously define a tree of requirements that specify a design configuration or an individual element.</p>

Req. ID	Req. Name	Text
RQT 1.2.3	Requirement Usage Identifier	Proposals for SysML v2 shall include a capability to represent each requirement in a requirement group with an identifier that is adaptable to a user defined numbering scheme, and that the user can specify whether the identifier can change or not.
RQT 1.2.4	Requirement Usage Ordering	<p>Proposals for SysML v2 shall include a capability to represent the order of each requirement in a requirement group that is not constrained by its requirement identifier.</p> <p>Supporting Information: This primarily allows the user to further organize the requirements, but it does not impact the meaning of the requirements. For example, there may be a requirement group with one requirement to open a valve and another requirement to close a valve. The user may want to order the open requirement as the first requirement in the group.</p>
RQT 1.3	Requirement Relationships Group	
RQT 1.3.1	Requirement Specialization	Proposals for SysML v2 shall include a capability to represent a generalization relationship that relates a specialized requirement definition to a more general requirement definition.
RQT 1.3.2	Requirement Satisfaction	<p>Proposals for SysML v2 shall include a capability to represent a satisfy relationship that relates a requirement to a model element that is asserted to satisfy it.</p> <p>Supporting Information: This is intended to be a specialization of the Conform Relationship.</p>
RQT 1.3.3	Requirement Verification	Proposals for SysML v2 shall include a capability to represent a verify relationship that relates a verification case to the requirement it is intended to verify.
RQT 1.3.4	Requirement Derivation	Proposals for SysML v2 shall include a capability to represent a derive relationship that relates a derived requirement to a source requirement.
RQT 1.3.5	Requirement Group Relationship	<p>Proposals for SysML v2 shall include a capability to represent a relationship between a requirement group and the members of the group that can include either a requirement or another requirement group.</p> <p>Supporting Information: This relationship groups requirements into a shared context.</p>

Req. ID	Req. Name	Text
RQT 1.3.6	Relationships to a Requirement Group	<p>Proposals for SysML v2 shall specify the meaning of relationships with a requirement group on each member of the requirement group.</p> <p>Supporting Information: This applies more generally to element groups.</p>
RQT 1.4	Requirement Supporting Information	<p>Proposals for SysML v2 shall include a capability to represent supporting information for a requirement, requirement definition, and a requirement group.</p> <p>Supporting Information: This is a kind of annotation that applies more generally to any model element.</p>
RQT 1.5	Goals, Objectives, and Evaluation Criteria	<p>Proposals for SysML v2 shall include a capability to represent goals, objectives, and evaluation criteria.</p> <p>Supporting Information:</p> <p>Criteria can be viewed as a superclass of a requirement that is used as a basis for evaluation, but does not specify specific values. For example, a cost requirement may be to require the cost to be less than a particular value, where-as a cost criterion may be to select a design with the lowest cost. Goals can be a type of criteria. For example, a goal of the system is to minimize the cost. An objective represents a desired end state. For example, the mission objective is to land a person on the moon and safely return them to earth. An objective can be thought of as a kind of requirement.</p> <p>Refer to Business Motivation Metamodel (BMM).</p>

Req. ID	Req. Name	Text
STC 1	Structure Requirements Group	<p>This group of requirements is intended to represent composable, deeply nested, connectible structure that supports definition of a family of configurations, specific configurations, and individual elements that are uniquely identified.</p> <p>Supporting Information:</p> <p>These requirements refer to definition elements and usage elements analogous to structured classifiers and classifier features in UML. A particular specialization of these concepts in SysML v1 is used to represent blocks and parts,</p> <p>The requirements also refer to configuration elements and individual elements. Configuration elements are used to unambiguously represent deeply nested structures as a tree of configuration elements. Individual elements are used to represent a particular element that can be uniquely identified, which is not to be interpreted as a UML or SysML instance. A particular system, such as a system with a serial number on the manufacturing floor, can be represented by an individual element which in turn can be represented as a tree of individual elements.</p> <p>The terms Component Definition and Component Usage refer to a particular kind of Definition Element and Usage Element that are analogous to a Block and Part in SysML v1. The terms Item Definition and Item Usage are also used to refer to a particular kind of Definition Element and Usage Element that correspond to something that flows through a system, such as Water. Component and Item are introduced in the Interface requirements section.</p>
STC 1.01	Modular Unit of Structure	<p>Proposals for SysML v2 shall include a capability to represent a modular unit of structure that defines its characteristics through value properties, interface ends (ports), constraints, and other structural and behavioral features.</p> <p>Supporting Information: The term used in this RFP to refer to a modular unit of structure is Definition Element. Such modular units of structure can be regarded as the fundamental named building blocks from which system representations, i.e. architectures, can be constructed. The capability enables modeling multiple levels of a hierarchy (e.g., system-of systems, system, subsystem and components) that can include logical and physical representations of hardware, software, information, people, facilities, and natural objects.</p> <p>The concept model refers many specializations of Definition Element. One example is the Component Definition which is intended to represent any level of a product structure. The concept model refers to an Item Definition as a specialized Definition Element to represent an element that flows through a system, such as water or a message. As noted above, the decomposition of Definition Elements may include variability that may be represented by multiplicity, subclasses, and/or a range of property values, which is removed when selecting a specific design configuration.</p>

Req. ID	Req. Name	Text
STC 1.02	Usage Element	Proposals for SysML v2 shall include a capability to represent the usage of a Definition Element, called a Usage Element, in order to support reuse in different contexts.
STC 1.03	Generic Hierarchical Structure	Proposals for SysML v2 shall include a capability to represent hierarchical composition structure of Definition and/or Usage Elements.
STC 1.04	Reference Element	Proposals for SysML v2 shall include a capability to represent a reference from one element to any other element within a shared scope.
STC 1.05	Multiplicity of Usage	<p>Proposals for SysML v2 shall include a capability to define the multiplicity of any particular Usage Element or Reference Element as an integer range (i.e., lower bound and upper bound).</p> <p>Supporting Information:</p> <p>Multiplicity refers to the number of Individual Elements.</p>
STC 1.06	Definition Element Specialization	Proposals for SysML v2 shall include a capability to represent a specialization from a more general Definition Element into a more specific Definition Element, where the more specific element inherits all features of the more general element.
STC 1.07	Unambiguous Deeply Nested Structure	Proposals for SysML v2 shall support a capability to unambiguously represent Usage Elements at any level of nesting.
STC 1.08	Structure With Variability	<p>Proposals for SysML v2 shall include a capability to represent multiple possible variant configurations of a system-of-interest with a single collection of Definition Elements and Usage Elements, where at each usage level in the (de)composition, a variant from different possible variant choices can be selected.</p> <p>Supporting Information: A Structure With Variability enables the definition of a product line architecture, see e.g. ISO 26550. Some common variant choices are defined by multiplicity range, sub-classes, and different values of a value property.</p>

Req. ID	Req. Name	Text
STC 1.10	Structure of an Individual	<p>Proposals for SysML v2 shall include a capability to represent a (de)composition of an Individual Element that is uniquely identifiable, and that can conform to an associated Structure resolved to a Single Variant and/or a Structure with Variability.</p> <p>Supporting Information: Such a digital representation of a real-world system is sometimes called a 'digital twin'. The elements in a Structure of an Individual are typically designated by a unique serial number, a batch number or an effectivity code.</p>
STC 1.11	Usage Specific Localized Type	<p>Proposals for SysML v2 shall include a capability to represent local override, redefinition, or addition of features with respect to the features defined by its more general type at any level of nesting.</p> <p>Supporting Information: The more-general to more-specific type chain is: Definition Element - direct Usage Feature - deeply nested Usage Feature - Configuration Element - Individual Element.</p> <p>The localized usage should support capabilities equivalent to redefinition and sub-setting for usage elements at any level of nesting.</p>
VRF 1	Verification and Validation Requirements Group	<p>The requirements in this group represent how to evaluate whether systems satisfy their requirements using verification methods.</p> <p>Supporting Information: The requirements for validation are not called out explicitly, but are intended to be supported in a similar way as the requirements for verification.</p>
VRF 1.1	Verification Context	<p>Proposals for SysML v2 shall include the capability to model a Verification Context that includes the unit-under-verification, the verification case, and the verification system and associated environment that performs the verification.</p>
VRF 1.2	Verification Case Group	
VRF 1.2.1	Verification Case	<p>Proposals for SysML v2 shall include the capability to model a verification case to evaluate whether one or more requirements are satisfied by a unit under verification.</p> <p>Supporting Information: This is intended to be a specialization of Case.</p>
VRF 1.2.2	Verification Objectives	<p>The verification case shall include verification objectives to be implemented by the verification activities.</p>

Req. ID	Req. Name	Text
VRF 1.2.3	Verification Success Criteria	The verification case shall include the criteria used to evaluate whether the verification objectives are met, the requirements are satisfied, and any subset of verification steps in a verification case are successfully performed.
VRF 1.2.4	Verification Methods	<p>The verification case shall include the methods used to verify the requirements. The methods, including inspection, analysis, demonstration, test, external verification, engineering reviews, and similarity, shall be included in a library. More than one method can be applied to verify a requirement.</p> <p>Supporting information:</p> <p>A verification method may include additional classification such as qualification test and acceptance test.</p> <p>An external verification is a method used in some industries, such as an Underwriters Labs.</p>
VRF 1.3	Verification System	Proposals for SysML v2 shall include the capability to model the system and associated environment that is used to verify the unit under verification. (Note: the verification system may include verification elements that are combinations of operational and simulated hardware, software, people, and facilities.)
VRF 1.4	Verification Relationships Group	
VRF 1.4.1	Verification Objectives to Verification Cases	Proposals for SysML v2 shall include the capability to model relationship between the verification cases and their verification objectives.
VRF 1.4.2	Validate Relationship	<p>Proposals for SysML v2 shall include the capability to model the relationship between the validation case and the model element being validated.</p> <p>Supporting Information: An element being validated may represent a requirement, design, as-built system, model, etc.</p> <p>The Verify Relationship is included in the requirements section.</p>

0.4.2 Non-Mandatory Language Requirements Table

Table 2. Non-Mandatory Language Requirements Table

Req. ID	Req. Name	Text
ANL 1	Analysis Requirements Group	

Req. ID	Req. Name	Text
ANL 1.10	Analysis Model - System Model Transformation	<p>Proposals for SysML v2 may include the capability to represent the transformation and the mapping between the analysis model and the system model.</p> <p>Supporting Information:</p> <p>This transformation will represent the algorithm or derivation process, if used, for generating analysis models from system model (or vice versa), and the mapping will provide a mechanism to verify and synchronize analysis models when the system model changes (or vice versa). Refer to the requirement for Model Mappings and Transformations under the Language Architecture and Formalism Requirements.</p>
ANL 1.12	Analysis Infrastructure	Proposals for SysML v2 may include the capability to represent the hardware, software, and the personnel (analysis experts) required for performing the analysis.
ANL 1.14	Decision Group	
ANL 1.14.1	Trade-off	Proposals for SysML v2 may include a capability to represent an evaluation among a set of alternatives that can result in a decision based on a set of criteria. A trade-off may be dependent on other decisions.
ANL 1.14.3	Decision Expression	Proposals for SysML v2 may include a capability to model decision expressions that constrain the possible decisions (e.g., alternative A OR (alternative B and alternative C)).
BHV 1	Behavior Requirements Group	
BHV 1.03	Function-based Behavior Group	
BHV 1.03.2	Composite Input and Output	<p>Proposals for SysML v2 may include the capability to model composite inputs and outputs of function-based behavior with separate flows defined for the constituent inputs and outputs.</p> <p>Supporting Information:</p> <p>Refer to a Simulink Bus Object and a Modelica Expandable Connector</p>

Req. ID	Req. Name	Text
BHV 1.03.5	Behavior Library	Proposals for SysML v2 may include a library that can be populated with commonly used behaviors to support execution that includes functions to store items, such as data and energy.
BHV 1.09	State History	<p>Proposals for SysML v2 may provide the capability to represent a state history of an individual element as a sequence of snapshots to describe how the individual element changes over time. The state history may contain a reference time scale consistent with QUDV, and can include a start time, end time, and time step.</p> <p>Supporting Information:</p> <p>A snapshot represents the state of an individual element at a point in time by capturing the values of each of its value properties. An example is a snapshot of a vehicle that may include the value of its position, velocity, and acceleration at a point in time, and the snapshot of its engine that may include the value of its power-out and temperature at the same point in time. The value properties that vary with time are also called state variables.</p> <p>The state history of a configuration element represents the default state history for each of its conforming individual elements.</p>
CNF 1	Conformance Requirements Group	
CNF 1.3	Model Interoperability Conformance	Proposals for SysML v2 shall provide test cases to assess conformance of a SysML v2 implementation with the SysML v2 model interchange, model mappings and transformations requirements in LNG 1.6.
CRC 1	Cross-cutting Requirements Group	
CRC 1.2	Model Element Group	
CRC 1.2.1	Model Element	Proposals for SysML v2 may include a root element that contains features that apply to all other kinds of elements in the model.
CRC 1.3	Model Element Relationships Requirements Group	

Req. ID	Req. Name	Text
CRC 1.3.11	Copy Relationship	<p>Proposals for SysML v2 may include a capability to represent a Copy Relationship where one side of the relationship refers to the element (or elements) being copied and the other side of the relationship refers to the copy (or copies).</p> <p>Supporting Information:</p> <p>The primary goals for this relationship are to establish provenance to support traceability, and to enable reuse of catalog items. This relationship provides the ability to copy elements such as a Container (e.g., package) and its contents, within a model and from one model to another. Additional constraints can be defined to specify the rules for what part of the element being copied can be modified in the copy. It is assumed that updates to the copied element are not propagated, unless there is a rule to support this.</p>
INF 1	Interface Requirements Group	
INF 1.07	Interface Agreement Group	
INF 1.07.3	Geometric Constraints	<p>Proposals for SysML v2 may provide the capability to constrain the interaction between the interface ends that include geometrical constraints on either Interface End.</p> <p>Supporting Information: An example are the geometric constraints associated with connecting a plug and socket.</p>
LNG 1	Language Architecture and Formalism Requirements Group	
LNG 1.2	Semantics Group	
LNG 1.2.1	Semantic Model Libraries	<p>Proposals for SysML v2 semantics may be modeled with SysML v2 model libraries.</p> <p>Supporting Information:</p> <ol style="list-style-type: none"> 1. Simplifies the language when model libraries are used to extend the base declarative semantics without additional abstract syntax. 2. Enables SysML to be improved and extended more easily by changes and additions to model libraries, rather than always through abstract syntax.

Req. ID	Req. Name	Text
LNG 1.2.2	Declarative Semantics	<p>Proposals for SysML v2 models may be grounded in a declarative semantics expressed using mathematical logic.</p> <p>Supporting Information:</p> <p>Semantics are defined formally to reduce ambiguity. Declarative semantics enable reasoning with mathematical proofs. This contrasts with operational semantics that requires execution in order to determine correctness.</p> <p>The semantics provide the meaning to the concepts defined in the language, and enable the ability to reason about the entity being represented by the models.</p>
LNG 1.2.3	Reasoning Capability	<p>Proposals for SysML v2 may provide a subset of its semantics that is complete and decidable.</p> <p>Supporting Information: This enables the ability to reason about the entity being modeled by querying the model, and returning results that satisfy the specified set of constraints.</p> <p>As an example, a query could return valid vehicle configurations that have a vehicle mass<2000kg AND vehicles that have a sunroof.</p>
LNG 1.4	Concrete Syntax Group	
LNG 1.4.4	Textual Concrete Syntax	<p>Proposals for SysML v2 may provide a standard human readable textual concrete syntax.</p> <p>Supporting information: Graphical and textual concrete syntax representations can be used in combination to more efficiently and effectively present the model. Refer to Alf as an example of a textual notation.</p>
LNG 1.5	Extensibility Group	
LNG 1.5.2	Extensibility Consistency	<p>Proposals for all SysML v2 extension mechanisms may be applicable to SysML v2 syntax (concrete and abstract) and semantics, and be consistent with how these are specified in SysML v2.</p> <p>Supporting Information:</p> <p>The SysML v2 Specification includes syntax, semantics, and vocabulary, so extending the language requires all of these to be extensible.</p>

Req. ID	Req. Name	Text
LNG 1.6	Model Interchange, Model Mapping, and Transformations Group	
LNG 1.6.1	Model Interchange	<p>Proposals for SysML v2 may provide a format for unambiguously interchanging the abstract syntax representation of a model and the concrete syntax representation of views of the model, which supports exchange of models that are created using either the metamodel or the profile.</p> <p>Supporting Information: The interchange should facilitate long term retention, file exchange, and version upgrades.</p> <p>Consider consistency with related interchange standards, such as AP233. For the concrete syntax, consider consistency with Diagram Definition and Diagram Interchange.</p>
LNG 1.6.2	Model Mappings and Transformations	<p>Proposals for SysML v2 may provide a capability to specify model mappings and transformations.</p> <p>Supporting Information: SysML may be used to represent the metamodel of other languages and data sources to enable transformation between SysML models, other data sources, and models in other languages. These languages include languages for queries, validation rules, expressions, viewpoint methods, and transformations.</p> <p>A common need is to map elements between SysML and Excel that supports import of Excel data into a SysML model, and export of SysML model elements to Excel. Another example is a mapping between SysML models and Simulink models.</p>
PRP 1	Properties, Values and Expressions Requirements Group	<html>
PRP 1.04	Logical Expressions	<p>Proposals for SysML v2 may include a capability to represent, as part of the Expression language, logical expressions that support as a minimum the standard boolean operators AND, OR, XOR, NOT, and conditional expressions like IF-THEN-ELSE and IF-AND-ONLY-IF, in which symbols bound to any characteristics (e.g. value properties or usage features) may be used.</p>

Req. ID	Req. Name	Text
PRP 1.09	Automated Quantity Value Conversion	<p>Proposals for SysML v2 may include a capability to represent all information necessary to perform automated conversion of the value of a quantity (typed by a numerical Value Type) expressed in one measurement scale to the value expressed in another compatible measurement scale with the same quantity kind.</p> <p>Supporting Information: This capability is needed to rebase a set of (smaller) system models coming from various contributors on a single coherent set of measurement scales, so that an integrated (larger) system model can be consistently constructed and analyzed.</p>
PRP 1.13	Discretely Sampled Function Value Type	<p>Proposals for SysML v2 may include a capability to represent variable length sets of values that constitute discrete time series data, frequency spectra, temperature dependent material properties, and any other datasets that can be represented through a discretely sampled mathematical function.</p> <p>Supporting Information: Such a discretely sampled function can be defined by a tuple of one or more Value Types that prescribe the type of the domain (independent) variables, and a tuple of one or more Value Types that prescribe the range (dependent) variables, as well as a variable length sequence of tuples that represent the actual set of sampled values.</p>
PRP 1.14	Discretely Sampled Function Interpolation	<p>Proposals for SysML v2 may include a capability to represent an interpolation scheme for a Discretely Sampled Function Value Type for derivation of the function's range values for domain values that are in-between sampled values.</p>
PRP 1.16	System Simulation Models	<p>Proposals for SysML v2 may include a capability to represent signal flow graph models and lumped parameter models as well as combinations thereof.</p> <p>Supporting Information: See [SysPISF] for details.</p> <p>This requirement is augmented by the analysis requirements.</p>
PRP 1.17	Across and Through Value Properties	<p><html></p> <p>Proposals for SysML v2 may include a capability to define across and through properties of flows on Interface Ends that participate in representing physical interactions in lumped parameter models.</p> <p>Supporting Information: Typically, the across and through properties are defined together as a pair, where the across property does not conserve energy and the through property does. For example, in a lumped parameter model of an electric circuit, the across and through properties are voltage and current respectively. See [SysPISF] for details.</p>

Req. ID	Req. Name	Text
PRP 1.18	Basic Geometry	<p>Proposals for SysML v2 may include a capability to represent basic two- and three-dimensional geometry of a structural element, including a base coordinate frame as well as relative orientation and placement of shapes through nested coordinate frame transformations, where the basic shape definitions are provided in a model library.</p> <p>Supporting Information: These capabilities are intended to provide basic geometry and coordinate frame representations to support specification of physical envelopes. The intent is that each block or equivalent will have its own reference coordinate system, and transformations can be applied between coordinate systems of different blocks. The shape of a block is defined as a property (e.g., 3-dimensional rectangular shape with length, height, and depth) whose values can be defined in its reference coordinate system.</p> <p>Consider references to standard formats (e.g., ISO 10303 (STEP), IGES)</p>
PRP 1.20	Equivalent Element	<p>Proposals for SysML v2 shall include a capability to represent an element that can reference another model element or an external element, indicating that the reference element is semantically equivalent to the referenced element.</p> <p>Supporting Information:</p> <p>This requirement is intended to be supported by transclusion, which enables the content that is referenced to be displayed in place of the reference element.</p> <p>A URI or URL can be used to refer to an external element.</p> <p>Example: Define a reference element 'x' that has a real value of 100.0. Transclude this reference element in "The top speed of this car shall be greater than <x> mph.", such that it is rendered textually as "The top speed of this car shall be greater than 100.0 mph."</p> <p>Example: A reference element called 'part A' refers to 'part A1' in a bill of materials in a PLM application</p> <p>SysML v1.X Constructs: Adjunct property (partial satisfaction)</p>
RML 1	Example Model and Model Libraries Group	

Req. ID	Req. Name	Text
RML 1.2	Model Libraries	<p>Proposals for SysML v2 may include Model Libraries that contain generic elements that can be further specialized to define domain specific libraries in the following domain areas:</p> <ul style="list-style-type: none"> • Primitive Value Types • Units and Quantity Kinds • Components • Natural environments • Interfaces • Behaviors • Requirements • Verification methods • Analyses • Basic geometric shapes • Basic material kinds • Viewpoint methods • View definitions (i.e. different kinds of documents and other artifacts) • Domain-specific symbols <p>Supporting information: The generic elements provide a common starting point for development of domain specific model libraries that can be elicited in future RFPs and/or the open source community.</p>
RQT 1	Requirement Group	
RQT 1.3	Requirement Relationships Group	
RQT 1.3.7	Relationship Logical Constraint	<p>Proposals for SysML v2 may include a capability to represent a logical expression (e.g. AND, OR, XOR, NOT, and conditional expressions like IF-THEN-ELSE and IF-AND-ONLY-IF) to one or more requirement relationships of the same kind, with an associated completeness property (e.g., complete satisfaction or partial satisfaction) and with a default expression of "And" for the logical expression.</p> <p>Supporting Information: As an example, two blocks that have a satisfy relationship with the same requirement are asserted to completely satisfy the requirement by default</p>
STC 1	Structure Requirements Group	

Req. ID	Req. Name	Text
STC 1.09	Structure Resolved to a Single Variant	<p>Proposals for SysML v2 may include a capability to represent a single variant of a system-of-interest as a tree of Configuration Elements that establishes a fully expanded hierarchical (de)composition that can conform to an associated Structure with Variability where a single selection is made for each variability choice (aka variation point).</p> <p>Supporting Information: A SysML v2 implementation should support auto-generation of a tree of configuration elements from a decomposition of definition elements with variability based on a set of rules. A SysML v2 implementation should ideally also provide a capability to semi-automatically generate the reverse transformation from a tree of configuration elements to a decomposition of definition elements.</p>
VRF 1	Verification and Validation Requirements Group	
VRF 1.2	Verification Case Group	
VRF 1.2.5	Verification Activity	<p>Proposals for SysML v2 may include a verification method that includes activities to collect the verification data, and include the ability to reference this data.</p> <p>Supporting Information: The data may be extensive and not captured directly in the model.</p>
VRF 1.2.6	Verification Evaluation Activity	<p>Proposals for SysML v2 may include a verification method that includes activities to evaluate the verification data and the verification success criteria and generate a verification result of how well the requirements are satisfied (e.g., pass/fail/unverified).</p>

0.4.3 Mandatory Language Requirements - Satisfied-by Table

Table 3. Mandatory Language Requirements - Satisfied-by Table

ID	Name	Satisfied?	Satisfied-by	Comment
ANL 1	Analysis Requirements Group			
ANL 1.01	Subject of the Analysis	Yes	Analyses	
ANL 1.02	Analysis	Partial	Analyses	need support to specify analysis model
ANL 1.03	Parameters of Interest	Partial	Analyses	need to identify moe, mop

ID	Name	Satisfied?	Satisfied-by	Comment
ANL 1.04	Analysis Case	Yes	Analyses	
ANL 1.05	Analysis Objectives	Yes	Analyses	
ANL 1.06	Analysis Scenarios	Yes	Analyses	
ANL 1.07	Analysis Assumption	Yes	Analyses	
ANL 1.08	Analysis Decomposition	Yes	Analyses	
ANL 1.09	Analysis Model	No		
ANL 1.11	Analysis Result	Partial	Analyses	
ANL 1.13	Analysis Metadata	No		
ANL 1.14	Decision Group			
ANL 1.14.2	Alternative	No		
ANL 1.14.4	Decision	No		
ANL 1.14.5	Criteria	No		
ANL 1.14.6	Rationale	No		
BHV 1	Behavior Requirements Group			
BHV 1.01	Behavior	Yes	Behaviors	
BHV 1.02	Behavior Decomposition	Yes	Behaviors	
BHV 1.03	Function-based Behavior Group			
BHV 1.03.1	Function-based Behavior	Partial	Actions	integrate seq diag, events
BHV 1.03.3	Function-based Behavior Constraints	Partial	Actions Constraints	constraint on start/edn snapshot

ID	Name	Satisfied?	Satisfied-by	Comment
BHV 1.03.4	Opaque Behavior	Partial	Actions Annotations TextualRepresentation	textual representation
BHV 1.03.6	Structure Modification Behavior	No		
BHV 1.04	State-based Behavior Group			
BHV 1.04.1	Regions, States, and Transitions	Yes	States	confirm state change can result from change in structure
BHV 1.04.2	Integration of Function-based Behavior with Finite State Behavior	Yes	States	
BHV 1.04.3	Integration of Constraints with Finite State Behavior	Yes	States Constraints	
BHV 1.05	Discrete and Continuous Time Behavior	Yes	Behaviors	
BHV 1.06	Events	Partial	Actions AcceptActionUsage States TransitionUsage	Signal events are supported, but not time or change events.
BHV 1.07	Control Nodes	Partial	Actions Control Nodes	Control nodes are supported on control flows, but not on item flows.
BHV 1.08	Time Constraints	No		
BHV 1.10	Behavior Execution	No		
BHV 1.11	Integration between Structure and Behavior			
BHV 1.11.1	Allocation of Behavior to Structure	Partial	Actions PerformActionUsage	need support for multiple parts participating in a single action (val case 4b)

ID	Name	Satisfied?	Satisfied-by	Comment
BHV 1.11.2	Integration of Control Flow and Input/Output Flow	Yes	Parts Actions States Connectors Succession Interactions ItemFlow	
BHV 1.11.3	Storing Items in Storage Elements Requirements Group			
BHV 1.11.3.1	Storage Element and Stored Item Usages	No		
BHV 1.11.3.2	Create, Modify, and Consume Stored Items	No		
BHV 1.12	Case	Yes	Cases	
CNF 1	Conformance Requirements Group			
CNF 1.1	Metamodel Conformance	No		
CNF 1.2	Profile Conformance	No		
CNF 1.3	Model Interoperability Conformance	No		
CNF 1.4	Traceability Matrix	Yes	1 SysML v2 Specific Requirements	
CRC 1	Cross-cutting Requirements Group			
CRC 1.1	Model and Model Library Group			
CRC 1.1.1	Model	Partial	Packages	Can use package, but no explicitly identified model construct
CRC 1.1.2	Model Library	Partial	Packages	Can use package, but no explicitly identified model library construct

ID	Name	Satisfied?	Satisfied-by	Comment
CRC 1.1.3	Container	Yes	Packages	
CRC 1.2	Model Element Group			
CRC 1.2.2	Unique Identifier	Yes	Elements	
CRC 1.2.3	Name and Aliases	Yes	Elements	
CRC 1.2.4	Definition / Description	Yes	Annotations	
CRC 1.2.5	Annotation	Partial	Annotations	Need link
CRC 1.2.6	Element Group	No		
CRC 1.2.7	Additional Cross-Cutting Concepts Group			
CRC 1.2.7.1	Problem	No		
CRC 1.2.7.2	Risk	No		
CRC 1.3	Model Element Relationships Requirements Group			
CRC 1.3.01	Relationship	Yes		
CRC 1.3.02	Derived Relationship	Not Determined		
CRC 1.3.03	Dependency Relationship	Yes	Dependencies	
CRC 1.3.04	Cause-Effect Relationship	No		
CRC 1.3.05	Explanation Relationship	No		
CRC 1.3.06	Conform Relationship	No		
CRC 1.3.07	Refine Relationship	No		
CRC 1.3.08	Allocation Relationship	No		

ID	Name	Satisfied?	Satisfied-by	Comment
CRC 1.3.09	Element Group Relationship	No		
CRC 1.3.10	Navigation Relationship	Not Planned		This is addressed by API xternal relationship service
CRC 1.4	Variability Modeling Group			
CRC 1.4.1	Variation Point	Yes	General	
CRC 1.4.2	Variant	Yes	General	
CRC 1.4.3	Variability Expression and Constraints	Yes	Constraints	
CRC 1.4.4	Variant Binding	No		
CRC 1.5	View and Viewpoint Group			
CRC 1.5.1	View Definition	Yes	Views	
CRC 1.5.2	Viewpoint	Yes	Views	
CRC 1.6	Metadata Group	No		
CRC 1.6.1	Version	Not Determined		Refer to API versioning service
CRC 1.6.2	Time Stamp	Not Determined		Refer to API versioning service
CRC 1.6.3	Data Protection Controls	Not Determined		Consider language extension that includes access control markings
INF 1	Interface Requirements Group			
INF 1.01	Interface Definition and Reuse	Yes	Interfaces	
INF 1.02	Interface Usage	Yes	Interfaces	
INF 1.03	Interface Decomposition	Yes	Interfaces	

ID	Name	Satisfied?	Satisfied-by	Comment
INF 1.04	Interface End Definitions	Yes	Ports	
INF 1.05	Conjugate Interface Ends	Yes	Ports	
INF 1.06	Item Definition	Partial	Items	need support for update rate
INF 1.07	Interface Agreement Group			
INF 1.07.1	Item Exchange Constraints	No		This will be addressed by conartaining transfers.
INF 1.07.2	Property Constraints	No		
INF 1.08	Interface Medium	No		
INF 1.09	Interface Layers	Not Determined		A layer is a kind of part with ports. Consider adding to model library.
INF 1.10	Allocating Functional Exchange to Interfaces	Partial		An interface can reference an item flow.
LNG 1	Language Architecture and Formalism Requirements Group			
LNG 1.1	Metamodel and Profile Group			
LNG 1.1.1	SysML Profile	Partial		The minimum requirements for a SysML v2 profile will be satisfied by the SysML v1 to SysML v2 transformation specification, which provides a way to represent SysML v1 concepts in SysML v2.
LNG 1.1.2	SysML Metamodel	Yes	1. Abstract Syntax	
LNG 1.1.3	Metamodel Specification	Partial	1. Abstract Syntax	
LNG 1.3	Abstract Syntax Group			
LNG 1.3.1	Syntax Specification	Partial	1. Abstract Syntax	concrete syntax in BNF

ID	Name	Satisfied?	Satisfied-by	Comment
LNG 1.3.2	View Independent Abstract Syntax	Yes	1. Abstract Syntax	
LNG 1.4	Concrete Syntax Group			
LNG 1.4.1	Concrete Syntax to Abstract Syntax Mapping	Partial		The textual syntax is informally mapped to the abstract syntax using Xtext.
LNG 1.4.2	Graphical Concrete Syntax	Yes		The standard graphical syntax is the textual syntax, which will be further extended to establish a standard graphical syntax.
LNG 1.4.3	Syntax Examples	No		
LNG 1.5	Extensibility Group			
LNG 1.5.1	Extension Mechanisms	No		
LNG 1.6	Model Interchange, Mapping, and Transformations Group			
LNG 1.6.3	UML Interoperability	Partial		This is being accomplished by the SysML v1 to SysML v2 transformation specification.
OTR 1	Interoperability Requirements Group			
OTR 2	Usability Group			
OTR 2.1	Usability Evaluation	Not Determined		
PRP 1	Properties, Values and Expressions Requirements Group			
PRP 1.01	Unified Representation of Values	Partial	Attributes Expressions	need to idettify constant
PRP 1.02	Value Type	Yes	Attributes	
PRP 1.03	Value Expression	Yes	Expressions TextualRepresentation	

ID	Name	Satisfied?	Satisfied-by	Comment
PRP 1.05	Unification of Expression and Constraint Definition	Yes	Constraints	
PRP 1.06	System of Quantities	Yes	Quantities and Units	
PRP 1.07	System of Units and Scales	Yes	Quantities and Units	
PRP 1.08	Range Restriction for Numerical Values	Yes	Constraints	
PRP 1.10	Primitive Data Types	Partial	ScalarValues	Missing enumerations
PRP 1.11	Variable Length Collection Value Types	Yes	NonScalarValues	
PRP 1.12	Compound Value Type	Yes	ScalarValues	
PRP 1.15	Probabilistic Value Distributions	No		
PRP 1.19	Materials with Properties	No		
RML 1	Example Model and Model Libraries Group			
RML 1.1	Example Model	No		
RQT 1	Requirement Group			
RQT 1.1	Requirement Definition Group			
RQT 1.1.1	Requirement Definition Name	Yes	Requirements	
RQT 1.1.2	Requirement Identifier	Partial	Requirements	not adaptable
RQT 1.1.3	Requirement Attributes	No		

ID	Name	Satisfied?	Satisfied-by	Comment
RQT 1.1.4	Textual Requirement Statement	Yes	Requirements	
RQT 1.1.5	Restricted Requirement Statement Group			
RQT 1.1.5.1	Restricted Requirement Statement	Not Planned		This can be addressed as a separate RFP.
RQT 1.1.5.2	Restricted Requirement Statement Extensibility	Not Planned		This can be addressed as a separate RFP.
RQT 1.1.5.3	Restricted Requirement Statement Transformation	Not Planned		This can be addressed as a separate RFP.
RQT 1.1.6	Formal Requirement Statement Group			
RQT 1.1.6.1	Formal Requirement Statement	Yes	Requirements	
RQT 1.1.6.2	Assumptions	Yes	Requirements	
RQT 1.2	Groups of Requirements			
RQT 1.2.1	Requirement Group	Partial	Requirements	
RQT 1.2.2	Requirement Usage (localized)	Yes	Requirements	
RQT 1.2.3	Requirement Usage Identifier	No		
RQT 1.2.4	Requirement Usage Ordering	Not Determined		Supported by feature ordering.
RQT 1.3	Requirement Relationships Group			
RQT 1.3.1	Requirement Specialization	Yes	Requirements	

ID	Name	Satisfied?	Satisfied-by	Comment
RQT 1.3.2	Requirement Satisfaction	Yes	Requirements	
RQT 1.3.3	Requirement Verification	No		
RQT 1.3.4	Requirement Derivation	No		
RQT 1.3.5	Requirement Group Relationship	No		
RQT 1.3.6	Relationships to a Requirement Group	No		
RQT 1.4	Requirement Supporting Information	Partial	Annotations	May require an explicit annotation kind for requirements.
RQT 1.5	Goals, Objectives, and Evaluation Criteria	Partial	Cases	Only objective is supported as part of Case.
STC 1	Structure Requirements Group			
STC 1.01	Modular Unit of Structure	Yes	Items Parts	
STC 1.02	Usage Element	Yes	General	
STC 1.03	Generic Hierarchical Structure	Yes	General	
STC 1.04	Reference Element	Yes	General	
STC 1.05	Multiplicity of Usage	Yes	Features	
STC 1.06	Definition Element Specialization	Yes	Types	
STC 1.07	Unambiguous Deeply Nested Structure	Yes	General	
STC 1.08	Structure With Variability	Yes	General	

ID	Name	Satisfied?	Satisfied-by	Comment
STC 1.10	Structure of an Individual	Yes	Individuals	
STC 1.11	Usage Specific Localized Type	Yes	General	
VRF 1	Verification and Validation Requirements Group			
VRF 1.1	Verification Context	No		
VRF 1.2	Verification Case Group			
VRF 1.2.1	Verification Case	Yes	Verifications	
VRF 1.2.2	Verification Objectives	Yes	Verifications	
VRF 1.2.3	Verification Success Criteria	No		
VRF 1.2.4	Verification Methods	No		
VRF 1.3	Verification System	No		
VRF 1.4	Verification Relationships Group			
VRF 1.4.1	Verification Objectives to Verification Cases	No		
VRF 1.4.2	Validate Relationship	No		

0.4.4 Non-Mandatory Language Requirements - Satisfied-by Table

Table 4. Non-Mandatory Language Requirements - Satisfied-by Table

ID	Name	Satisfied?	Satisfied-by	Comment
ANL 1	Analysis Requirements Group			
ANL 1.10	Analysis Model - System Model Transformation	No		external relationship service
ANL 1.12	Analysis Infrastructure	Not Planned		

ID	Name	Satisfied?	Satisfied-by	Comment
ANL 1.14	Decision Group			
ANL 1.14.1	Trade-off	No		
ANL 1.14.3	Decision Expression	No		
BHV 1	Behavior Requirements Group			
BHV 1.03	Function-based Behavior Group			
BHV 1.03.2	Composite Input and Output	Not Determined		
BHV 1.03.5	Behavior Library	Not Determined		
BHV 1.09	State History	Yes	Individuals	
CNF 1	Conformance Requirements Group			
CNF 1.3	Model Interoperability Conformance	No		
CRC 1	Cross-cutting Requirements Group			
CRC 1.2	Model Element Group			
CRC 1.2.1	Model Element	Not Determined		
CRC 1.3	Model Element Relationships Requirements Group			
CRC 1.3.11	Copy Relationship	Not Planned		
INF 1	Interface Requirements Group			
INF 1.07	Interface Agreement Group			
INF 1.07.3	Geometric Constraints	Not Determined		
LNG 1	Language Architecture and Formalism Requirements Group			
LNG 1.2	Semantics Group			
LNG 1.2.1	Semantic Model Libraries	Yes	Kernel Library	
LNG 1.2.2	Declarative Semantics	Yes	Kernel Library	
LNG 1.2.3	Reasoning Capability	Partial		

ID	Name	Satisfied?	Satisfied-by	Comment
LNG 1.4	Concrete Syntax Group			
LNG 1.4.4	Textual Concrete Syntax	Yes		
LNG 1.5	Extensibility Group			
LNG 1.5.2	Extensibility Consistency	No		
LNG 1.6	Model Interchange, Model Mapping, and Transformations Group			
LNG 1.6.1	Model Interchange	No		
LNG 1.6.2	Model Mappings and Transformations	Not Determined		
PRP 1	Properties, Values and Expressions Requirements Group			
PRP 1.04	Logical Expressions	Yes	Control Functions	
PRP 1.09	Automated Quantity Value Conversion	Yes	Quantities and Units	
PRP 1.13	Discretely Sampled Function Value Type	No		
PRP 1.14	Discretely Sampled Function Interpolation	Not Planned		
PRP 1.16	System Simulation Models	Not Determined		
PRP 1.17	Across and Through Value Properties	No		
PRP 1.18	Basic Geometry	No		
PRP 1.20	Equivalent Element	No		
RML 1	Example Model and Model Libraries Group			
RML 1.2	Model Libraries	No		
RQT 1	Requirement Group			
RQT 1.3	Requirement Relationships Group			
RQT 1.3.7	Relationship Logical Constraint	No		
STC 1	Structure Requirements Group			

ID	Name	Satisfied?	Satisfied-by	Comment
STC 1.09	Structure Resolved to a Single Variant	Not Determined		
VRF 1	Verification and Validation Requirements Group			
VRF 1.2	Verification Case Group			
VRF 1.2.5	Verification Activity	No		
VRF 1.2.6	Verification Evaluation Activity	No		

0.4.5 Changed Language Requirements Table

Table 5. Changed Language Requirements Table

ID	Name	Requirement Text	Change Status	Change Description
ANL 1.13	Analysis Metadata	Proposals for SysML v2 shall include the capability to represent the metadata relevant to specifying the analysis, including the specification of dependent and independent parameters.	Modified	June 14, 2018 - Modified by adding text starting at "including the specification...". Drivers based on SysML v1.6 RTF Out of Scope Issues, SYSML16-38: Inability to represent dependent, independent parameters on constraint properties
BHV 1.11.3	Storing Items in Storage Elements Requirements Group		Added	16 June 2018 - Added this requirement group to mandatory requirements to provide a requirement group for BHV 1.11.3.1 and BHV 1.11.3.2

ID	Name	Requirement Text	Change Status	Change Description
BHV 1.11.3.1	Storage Element and Stored Item Usages	<p>Proposals for SysML v2 shall include the capability to model a storage element that can store items declared by stored item usages. The stored items shall be identified as conserved (e.g., a physical element) or copied (e.g., data from memory). Conservation constraints shall apply to conserved item usages (e.g., amount in - amount out=amount stored).</p> <p>Supporting Information: Examples include:</p> <p>A storage element called tank that stores a stored item usage called fluid. (example of a conserved stored item usage)</p> <p>A storage element called common value table that stores a stored item usage called system mode. (example of a copied stored item usage)</p>	Added	16 June 2018 - Added to mandatory requirements based on Creating and Accessing Stored Items Use Case
BHV 1.11.3.2	Create, Modify, and Consume Stored Items	<p>Proposals for SysML v2 shall include the capability to model outputs and inputs of a behavior that create, modify, or consume stored items of a storage element. An input to or output from a storage element that results in the creation, modification, or consumption of stored items can be assigned to one or more ports of the storage element.</p> <p>Supporting Information: Examples include:</p> <p>A pump fluid action produces an output called fluid that is stored in a tank, and another action consumes the fluid from the tank. (example of a conserved stored item usage)</p> <p>An update mode variable action produces a logical data item that is stored in common value table, and another action called verify mode consumes the logical data item from the common value table. (example of a copied stored item usage)</p>	Added	16 June 2018 - Added to mandatory requirements based on Creating and Accessing Stored Items Use Case

ID	Name	Requirement Text	Change Status	Change Description
CNF 1	Conformance Requirements Group		Added	26 April 2018 - Added this requirement group to non-mandatory to provide a group for CNF 1.3
CNF 1.3	Model Interoperability Conformance	Proposals for SysML v2 shall provide test cases to assess conformance of a SysML v2 implementation with the SysML v2 model interchange, model mappings and transformations requirements in LNG 1.6.	Added Modified Moved	26 April 2018 - Moved from Mandatory requirements and replaced text "interoperability specification" with "interchange, model mappings and transformations requirements in LNG 1.6"
CNF 1.3	Model Interoperability Conformance	Proposals for SysML v2 shall provide test cases to assess conformance of a SysML v2 implementation with the SysML v2 model interoperability specification.	Deleted Moved	26 April 2018 - Moved to Non-mandatory

ID	Name	Requirement Text	Change Status	Change Description
PRP 1.20	Equivalent Element	<p>Proposals for SysML v2 shall include a capability to represent an element that can reference another model element or an external element, indicating that the reference element is semantically equivalent to the referenced element.</p> <p>Supporting Information:</p> <p>This requirement is intended to be supported by transclusion, which enables the content that is referenced to be displayed in place of the reference element.</p> <p>A URI or URL can be used to refer to an external element.</p> <p>Example: Define a reference element 'x' that has a real value of 100.0. Transclude this reference element in "The top speed of this car shall be greater than <x> mph.", such that it is rendered textually as "The top speed of this car shall be greater than 100.0 mph."</p> <p>Example: A reference element called 'part A' refers to 'part A1' in a bill of materials in a PLM application</p> <p>SysML v1.X Constructs: Adjunct property (partial satisfaction)</p>	Added	14 June 2018 - Added this new requirement based on the use case for semantic reference to an internal or external model element (or set of model elements).
STC 1.03	Generic Hierarchical Structure	Proposals for SysML v2 shall include a capability to represent hierarchical composition structure of Definition and/or Usage Elements.	Modified	25 Oct 2018 - Changed the last few words of the requirement text from "structure of Definition Elements" to "structure of Definition and/or Usage Elements".
VRF 1.2.3	Verification Success Criteria	The verification case shall include the criteria used to evaluate whether the verification objectives are met, the requirements are satisfied, and any subset of verification steps in a verification case are successfully performed.	Modified	3 Dec 2018 Added text to end of requirement statement "and any subset of verification steps..."

1 Scope

The purpose of this standard is to specify the Systems Modeling Language™ (SysML), to guide the implementation of conformant modeling tools, and to provide the basis for the development of material and other resources to train users in the application of SysML. It also serves as the baseline for future revisions of SysML.

SysML is a general-purpose modeling language for modeling systems that is intended to facilitate a model-based systems engineering (MBSE) approach to engineer systems. It provides the capability to create and visualize models that represent many different aspects of a system including its requirements, structure, behavior, and the constraints on its system properties to support engineering analysis.

The language is intended to support multiple systems engineering methods and practices. The specific methods and practices may impose additional constraints on how the language is used. SysML is defined as an extension of the Kernel Modeling Language (KerML), which provides a common, domain-independent language for building semantically rich and interoperable modeling languages. SysML also provides a capability to provide further language extensions. It is anticipated that SysML will be customized using this language extension mechanism to model more specialized domain-specific applications, such as automotive, aerospace, healthcare, and information systems, as well as discipline specific extensions such as safety and reliability.

Note. Definitions of *system* and *systems engineering* can be found in ISO/IEC 15288.

SysML Version 2 is intended to enhance the precision, expressiveness, interoperability, and the consistency and integration of the language relative to SysML Version 1. SysML also includes a textual notation in addition to a graphical notation that was not provided with SysML v1. SysML v2 is specified as a metamodel that extends the kernel metamodel provided by KerML, which is greatly simplified compared to the UML metamodel that the SysML v1 profile was based. In order to facilitate the transition from SysML v1 to SysML v2, the standard also specifies a formal transformation from UML models using the SysML v1 profile to models using the SysML v2 metamodel.

2 Conformance

This specification defines the Systems Modeling Language (SysML), a language used to construct *models* of systems (whether they are real, planned or imagined). The specification comprises this document together with the content of the machine-readable files listed on the cover page. If there are any conflicts between this document and the machine-readable files, the machine-readable files take precedence.

A *SysML model* shall conform to this specification only if it can be represented according to the syntactic requirements specified in [Clause 7](#). The model may be represented in a form consistent with the requirements for the SysML concrete syntax, in which case it can be parsed (as specified in [Clause 7](#)) into an abstract syntax form, or it may be represented directly in an abstract syntax form.

A *SysML modeling tool* is a software application that creates, manages, analyzes, visualizes, executes or other performs other services on SysML models. A tool can conform to this specification in one or more of the following ways.

1. *Abstract Syntax Conformance.* A tool demonstrating Abstract Syntax Conformance provides a user interface and/or API that enables instances of SysML abstract syntax metaclasses to be created, read, updated, and deleted. The tool must also provide a way to validate the well-formedness of models that corresponds to the constraints defined in the SysML metamodel. A well-formed model represented according to the abstract syntax is syntactically conformant to SysML as defined above. (See [Clause 7](#).)
2. *Concrete Syntax Conformance.* A tool demonstrating Concrete Syntax Conformance provides a user interface and/or API that enables instances of SysML concrete syntax notation to be created, read, updated, and deleted. Note that a conforming tool may also provide the ability to create, read, update and delete additional notational elements that are not defined in SysML. Concrete Syntax Conformance implies Abstract Syntax Conformance, in that creating models in the concrete syntax acts as a user interface for the abstract syntax. However, a tool demonstrating Concrete Syntax Conformance need not represent a model internally in exactly the form modeled for the abstract syntax in this specification. (See [Clause 7](#).)
3. *Semantic Conformance.* A tool demonstrating Semantic Conformance provides a demonstrable way to interpret a syntactically conformant model (as defined above) according to the SysML semantics, e.g., via semantic model analysis or model execution. Semantic Conformance implies Abstract Syntax Conformance, in that the semantics for SysML are only defined on well-formed models represented in the abstract syntax. (See [Clause 7](#) and [8.1](#). See also [KerML, 6.1] for further discussion of the interpretation of models and their syntactic and semantic conformance.)
4. *Model Interchange Conformance.* A tool demonstrating model interchange conformance can import and/or export syntactically conformant SysML models (as defined above) in one or more of the formats specified in [KerML, Clause 9].

Every conformant SysML modeling tool shall demonstrate at least Abstract Syntax Conformance and Model Interchange Conformance. In addition, such a tool may demonstrate Concrete Syntax Conformance and/or Semantic Conformance, both of which are dependent on Abstract Syntax Conformance. The tool may also provide one or more of the following additional capabilities, conformant with this specification:

1. *Domain Library Support.* In addition to the Systems Model Library, a conformant tool may provide one or more domain model libraries as specified in [Clause 8](#).
2. *SysML v1 Transformation Support.* A conformant tool may provide the capability to import a model conformant with SysML v1 and, at least, export the model into one of the valid model interchange formats for SysML v2, as specified in [Annex C](#). For the purposes of this conformance point, "SysML v1"

shall mean at least SysML v1.7, and optionally earlier versions, and "SysML v2" shall mean the latest version of SysML as of v2.0 or later.

For a tool to demonstrate any of the above forms of conformance, it is sufficient that the tool pass the relevant tests from the Conformance Test Suite specified in [Annex A](#).

3 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this specification.

[KerML] *Kernel Modeling Language (KerML)*, Version 1.0
(as submitted with this proposed specification)

[MOF] *Meta Object Facility*, Version 2.5.1
<https://www.omg.org/spec/MOF/2.5.1>

[OCL] *Object Constraint Language*, Version 2.4
<https://www.omg.org/spec/OCL/2.4>

[SMOF] *MOF Support for Semantic Structures*, Version 1.0
<https://www.omg.org/spec/SMOF/1.0>

[SysMLv1] *OMG Systems Modeling Language (SysML)*, Version 1.7
(currently in preparation)

[UML] *Unified Modeling Language (UML)*, Version 2.5.1
<https://www.omg.org/spec/UML/2.5.1>

The following references were used in the definition of the Quantities and Units model library (see [8.2](#)):

[GUM] JCGM 100:2008 and ISO/IEC Guide 98-3, Evaluation of measurement data - Guide to the expression of uncertainty in measurement
<https://www.bipm.org/en/publications/guides/#gum>

[ISO 80000-1] ISO 80000-1:2009, Quantities and units - Part 1: General
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-1:ed-1:v1:en>

[ISO 80000-2] ISO 80000-2:2019, Quantities and units - Part 2: Mathematical signs and symbols to be used in the natural sciences and technology
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-2:ed-2:v1:en>

[ISO 80000-3] ISO 80000-3:2019, Quantities and units - Part 3: Space and Time
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-3:ed-2:v1:en>

[ISO 80000-4] ISO 80000-4:2019, Quantities and units - Part 4: Mechanics
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-4:ed-2:v1:en>

[ISO 80000-5] ISO 80000-5:2019, Quantities and units - Part 5: Thermodynamics
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-5:ed-2:v1:en>

[IEC 80000-6] IEC 80000-6:2008, Quantities and units - Part 6: Electromagnetism
<https://www.iso.org/obp/ui/#iso:std:iec:80000:-6:ed-1:v1:en,fr>

[ISO 80000-7] ISO 80000-7:2019, Quantities and units - Part 7: Light
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-7:ed-2:v1:en>

[ISO 80000-8] ISO 80000-8:2020, Quantities and units - Part 8: Acoustics
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-8:ed-2:v1:en>

[ISO 80000-9] ISO 80000-9:2019, Quantities and units - Part 9: Physical chemistry and molecular physics
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-9:ed-2:v1:en>

[ISO 80000-10] ISO 80000-10:2019, Quantities and units - Part 10: Atomic and nuclear physics
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-10:ed-2:v1:en>

[ISO 80000-11] ISO 80000-11:2019, Quantities and units - Part 11: Characteristic numbers
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-11:ed-2:v1:en>

[ISO 80000-12] ISO 80000-12:2019, Quantities and units - Part 12: Solid state physics
<https://www.iso.org/obp/ui/#iso:std:iso:80000:-12:ed-2:v1:en>

[IEC 80000-13] IEC 80000-13:2008, Quantities and units - Part 13: Information science and technology
<https://www.iso.org/obp/ui/#iso:std:iec:80000:-13:ed-1:v1:en>

[IEC 80000-14] IEC 80000-14:2008, Quantities and units - Part 14: Telebiometrics related to human physiology
<https://www.iso.org/obp/ui/#iso:std:iec:80000:-14:ed-1:v1:en>

[NIST SP-811] NIST Special Publication 811, The NIST Guide for the use of the International System of Units
(In particular its Appendix B "Conversion Factors")
<https://www.nist.gov/pml/special-publication-811>

[VIM] JCGM 200:2012 and ISO/IEC Guide 99, International vocabulary of metrology - Basic and general concepts and associated terms (VIM)
<https://www.bipm.org/en/publications/guides/#vim>

4 Terms and Definitions

There are no terms and definitions specific to this specification.

5 Symbols

There are no symbols defined in this specification.

6 Introduction

6.1 Language Overview

As shown in [Fig. 1](#), SysML is built as an extension to the Kernel metamodel from [KerML]. The SysML abstract syntax (see [Clause 7](#)) extends the Kernel abstract syntax, providing specialized constructs for modeling systems. Further, the SysML Systems Model Library (see [8.1](#)) extends the Kernel Model Library to provide the semantic specification for SysML (see also [KerML, 7.1] on the use of model libraries for semantic specification). Finally, SysML provides an additional set of Domain Libraries (see [Clause 8](#)) to provide a rich set of reference models in various domains important to systems modeling (such as Quantities and Units and Basic Geometry).

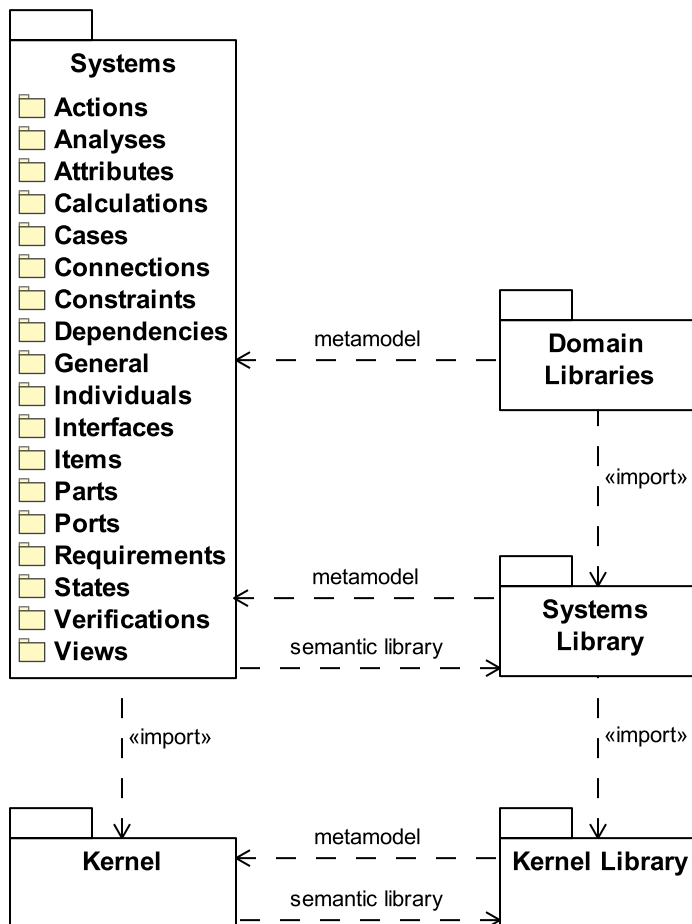


Figure 1. SysML Language Architecture

6.2 Document Conventions

The following stylistic conventions are applied in the abstract syntax, concrete syntax and semantics descriptions of [Clause 7](#) (Metamodel) and in the element descriptions of [Clause 8](#) (Model Library) when model elements are referenced by name in body text paragraphs. However, they are generally *not* used in overview subclauses, which are written in a more descriptive and colloquial style, and should be considered informative rather than normative.

1. Names of metaclasses from the SysML abstract syntax model are capitalized and written exactly as defined in the abstract syntax, but they are otherwise used as if they were nouns in English, e.g.,

"PartDefinition, "ActionUsage". When used in this way, the metaclass name refers to the instances of the metaclass (in models), e.g., "A PartUsage must be defined by a PartDefinition". This can be modified using the "metaclass" as necessary to refer to the metaclass itself instead of its instances, e.g., "The PartDefinition metaclass is contained in the Parts package."

2. Names of properties of metaclasses in the text are styled in a "code" font, and used as if they are English nouns, pluralized where necessary, e.g., "the ownedParts of a Definition".
3. Names of classes and features of elements from a SysML model are styled the same as abstract syntax metaclass and property names, but put in italics. This includes elements from any of the SysML Model Libraries (e.g., "Action" and "quantity") and elements referenced from sample user models (e.g., "Vehicle" and "wheels").

In addition, the following additional conventions used in the Concrete Syntax subclauses within [Clause 7](#) for the SysML textual notation.

1. In all cases, text in the SysML textual notation is styled in a "code" font.
2. When individual keywords are referenced, they are written in boldface, e.g., "PartUsages are declared using the **part** keyword."
3. Symbols (such as ~ and :>>) and short segments of textual notation (but longer than an individual name) may be written in-line in body text (without being italic or bold).
4. Longer samples of textual notation are written in separate paragraphs, indented relative to body paragraphs.

The grammar of the textual Concrete Syntax and its mapping to the Abstract Syntax is specified using a specialized *Extended Backus-Naur Form* (EBNF) notation that is described in [KerML, 7.1.3]. For the graphical Concrete Syntax, this BNF notation is further extended to allow the use of graphical symbols within productions.

Submission Note. A paragraph marked as a "submission note" (like this one) is not to be considered part of the formal specification being proposed. Rather, it is a note describing either material that was not included at the time of the initial submission of the proposed specification, or changes to the specification that are expected before the revised submission of the proposal. Such notes will be removed in future revised submissions as the issues they address are resolved.

Implementation Note. A paragraph marked as an "implementation note" (like this one) is also not to be considered part of the formal specification being proposed. Rather, it describes an area in which the proof-of-concept pilot implementation being developed by the submission team is not fully consistent with what is being proposed in the specification as of the time of the submission.

Release Note. Paragraphs marked like this one provide additional information on the status of updates to this specification document in releases since the initial submission.

6.3 Document Organization

The rest of this document is organized into two major clauses.

- [Clause 7](#) specifies the Metamodel that defines the SysML language. The first subclause of this clause is an overview, followed by a summary of the Kernel metamodel on which the rest of the SysML metamodel is built. The Kernel metamodel has the same abstract syntax and semantics as the metamodel for the Kernel Modeling Language (KerML), as defined in [KerML]. However, the textual concrete syntax for the Kernel is not identical to that for KerML, and SysML also provides a graphical concrete syntax for certain Kernel elements. Each subclause following the Kernel summary then describes each of the packages in the SysML metamodel proper, including the concrete syntax, abstract syntax, and semantics for the metamodel elements in each package.

- [Clause 8](#) specifies a set of model libraries defined in SysML itself. The Systems Model Library extends the Kernel Model Library from [KerML] in order to provide systems-modeling-specific semantics to SysML language constructs. The other model libraries (such as Quantities and Units) provide rich domain-specific models on which users can draw when creating their own models. Each model library is described with a set of subclauses to describe the content of each of the top-level packages in the model library, referred to as its *library models*.

These clauses are followed by three annexes.

- [Annex A](#) defines the suite of conformance tests that may be used to demonstrate the conformance of a modeling tool to this specification (see also [Clause 2](#)).
- [Annex B](#) is an informative annex that presents a realistic extended example model using the SysML language as defined in this specification.
- [Annex C](#) defines the a formal transformation from SysML v1 models to SysML v2 models that, to the greatest extent possible, preserves the semantics of the original models.

In addition, Clause 9 of [KerML] on Model Interchange is included by reference as a normative part of this specification, in order to define allowable methods for interchanging SysML models.

6.4 Acknowledgements

The primary authors of this specification document and the syntactic and semantic models defined in it are:

- Sanford Friedenthal, SAF Consulting
- Ed Seidewitz, Model Driven Solutions
- Yves Bernard, Airbus
- Tim Weilkiens, oose
- Hans Peter de Koning, DEKonsult

The specification was formally submitted for standardization by the following organizations:

- 88Solutions Corporation
- Dassault Systèmes
- GfSE e.V.
- IBM
- INCOSE
- InterCax LLC
- Lockheed Martin Corporation
- MITRE
- Model Driven Solutions, Inc.
- PTC
- Simula Research Laboratory AS
- Thematrix

However, work on the specification was also supported by over 120 people in over 60 other organizations that participated in the SysML v2 Submission Team (SST), by contributing use cases, providing critical review and comment, and validating the language design. The following individuals had leadership roles in the SST:

- Manas Bajaj, InterCax LLC (API and services development lead)
- Yves Bernard, Airbus (profile development co-lead)
- Bjorn Cole, Lockheed Martin Corporation (metamodel development co-lead)
- Sanford Friedenthal, SAF Consulting (SST co-lead, requirements V&V lead)
- Charles Galey, Lockheed Martin Corporation (metamodel development co-lead)
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- Ed Seidewitz, Model Driven Solutions (SST co-lead, pilot implementation lead)
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- Zoltán Ujhelyi, IncQuery Labs

7 Metamodel

7.1 Overview

The SysML metamodel defined in this clause contains concepts that are used to model systems, their components, and the external environment in a context.

The SysML metamodel extends the KerML metamodel as specified in the KerML specification [KerML]. The most basic KerML metaclasses are Element and Relationship. All other KerML metaclasses are specializations of these elements. The SysML metamodel imports the KerML metamodel and reuses some KerML metaclasses directly, and further specializes other KerML metaclasses. The subclauses that follow summarize the description of the KerML concepts in [7.2](#), and specify the SysML metaclasses in [7.3](#) through [7.20](#).

SysML directly reuses the Package, Import, and Membership metaclasses from KerML to provide a flexible means to logically organize a model into a containment tree. SysML reuses and extends Classifier, Feature, Association, Connector, Behavior, Functions, Expressions, and other KerML metaclasses. SysML also reuses Generalization that provides the mechanism to support subclassing, subsetting and redefining elements, which are all KerML concepts.

The general pattern of a Definition element and Usage element is applied to many of the SysML language constructs to facilitate reuse. The Definition element is a kind of KerML Classifier and the UsageElement is a kind of KerML Feature. The Definition element and Usage element are metaclasses that are further subclassed in the SysML metamodel to create other metaclasses such as PartDefinition and PartUsage. The SysML Model Library includes instances of these metaclasses. For example, instances of the metaclasses PartDefinition and PartUsage are contained in the SysML Model Library as Part and parts respectively. These are the specific constructs used to develop a model of a system. The Part and parts from the library are further specialized to create particular part definitions and part usages, such as a part called vehicle that is defined by a part definition called Vehicle.

The definition elements and usage elements facilitate model reuse, such that a concept can be defined once and then used in many different contexts. For example, a front wheel and a rear wheel can be represented as two different usages of the same definition of Wheel. A usage element can also be further specialized for its specific context. For example, the front wheels and rear wheels may be usages of the same definition of Wheel, but have different kinds of tires with different tire pressures.

The modeling constructs specific to SysML, as specified in subclauses [7.3](#) through [7.20](#), are built on the KerML foundation, and cover the following areas:

- Fundamental aspects of constructing a model, including:
 - The modeling of *dependencies* between modeling elements (see [7.3](#)).
 - The basic concepts of *definition* and *usage*, as discussed above (see [7.4](#)).
 - The modeling of *variability*, which includes the definition of *variation* points within a model where choices can be made to select a specific *variant*, and the selection of a particular variant may constrain the allowable choices at other variation points. A system can be *configured* by making appropriate choices at each of the variation points of a variability model, consistent with specified constraints. Variation points can be defined in any of the specific modeling areas listed below, so the ability to model variability is built into the base syntax of definitions and usages (see [7.4](#)).
- The modeling of *structure* to represent how parts are decomposed, interconnected and classified, and includes:
 - *Attributes* that specify characteristics of something that can be defined by simple or compound data types, and dimensional quantities such as mass, length, etc. (see [7.5](#)).
 - *Items* that may flow through a process or system or be stored by a system (see [7.6](#)).
 - *Parts* are the foundational units of structure that can be composed and interconnected, forming composite parts and entire systems (see [7.7](#)).

- *Ports* that define connection points on parts that enable interactions between parts (see [7.8](#)).
- *Connections* (see [7.9](#)) and *interfaces* (see [7.10](#)) that define how parts are interconnected.
- The modeling of *individual* items and parts with identity, which can be represented at specific points in time, over a duration in time, or over an entire lifetime (see [7.11](#)).
- The modeling of *behavior*, which specify how systems and or components interact and include:
 - *Actions* performed by a part, including their temporal ordering, and the flows of items between them (see [7.12](#)).
 - *States* exhibited by a part, the allowable *transitions* between those states, and the actions enabled in a state or during a transition (see [7.13](#)).
- The modeling of *calculations* which are parameterized expressions that can be computed to produce specific results (see [7.14](#)).
- The modeling of *constraints*, which specify conditions that a system or part is expected or required to satisfy, and can be evaluated as true or false, or asserted to be true (see [7.15](#)).
- The modeling of *requirements*, which is a special kind of constraint that a *subject* system or part must satisfy to be a valid solution (see [7.16](#)).
- The modeling of *cases*, which define the steps required to produce a desired result relative to a *subject* (see [7.17](#)), to achieve a specific *objective*, including:
 - *Analysis cases*, whose steps are the *actions* necessary to analyze a subject (see [7.18](#)).
 - *Verification cases*, whose objective is to verify how a requirement is satisfied by the subject (see [7.19](#)).
- The modeling of *viewpoints* that specify information of interest by a set of stakeholders, and *views* that specify a query of the model, and a rendering of the query results, that is intended to satisfy a particular viewpoint (see [7.20](#)).

In a similar way that SysML extends KerML, SysML also provides a language extension capability to allow users to build domain and user-specific extensions of SysML, both syntactically and semantically. This allows SysML to be highly adaptable for specific application domains and user needs, while maintaining a high level of underlying standardization and tool interoperability. (See [7.21](#).)

It should be noted that SysML does not contain specific language constructs called system, subsystem, assembly, component, and many other commonly used terms. An entity with structure and behavior in SysML is represented as a part (see [7.7](#)). The language provides straightforward extension mechanisms to specify terminology that is appropriate for the domain of interest.

7.2 Kernel

7.2.1 Basic Elements

7.2.1.1 Basic Elements Overview

The SysML metamodel reuses basic elements from the KerML Root that includes Element and Relationship. All other KerML and SysML model elements are extensions of these basic elements.

An element has a unique identifier. Elements can have a name and any number of aliases.

A relationship is a kind of element that relates other elements. Some relationships are constrained to have two ends (i.e., binary relationship) while others are not (e.g., Association and Connector in the Kernel, Dependency and Expose in SysML). The ends on relationships are ordered. A directed relationship designates its ends as sources and targets.

7.2.1.2 Basic Elements Concrete Syntax

7.2.1.2.1 Basic Elements Textual Notation

```
Identification (e : Element, m : Membership) =  
  ( 'id' e.humanId = NAME )? ( m.memberName = NAME )?
```

SysML does not provide any concrete syntax for generic Elements or Relationships that are not instances of a more specialized metaclass. While the Element and Relationship metaclasses are not abstract in the KerML abstract syntax (for reasons discussed in [KerML, 7.2.2.1]), they shall not be directly instantiated in a SysML model.

However, the SysML concrete syntax does provide a consistent notation for identifying any kind of element, in one or both of the following ways:

- The declaration of an Element may specify a `humanId` for it, as a lexical name preceded by the keyword **id**. Note that the `humanId` of an Element is separate from the unique `identifier` or other `aliasIds` of an Element that are managed by the underlying modeling tooling. It is the responsibility of the modeler to maintain other structural or uniqueness properties for `humanIds` as appropriate to the model being created.
- If the Element is an `ownedMember` of a Package, then a name may also be given for the Element (after its `humanId`, if any). This name is actually the `memberName` of the Membership by which the Element is owned by the Package (see [7.2.3](#)).

Note that it is not required to specify either a `humanId` or a name for an Element. However, unless at least one of these is given, it is not possible to reference the Element from elsewhere in the textual concrete syntax.

7.2.1.2.2 Basic Elements Graphical Notation

```
id-text (e : Element) =  
  ( 'uuid' NAME(e.identifier) )? ( 'id' NAME(e.aliasId) ) * NAME(e.name)?  
  
qualified-name-text (e : Element) =  
  ( qualified-name-text (e.owningNamespace) '::' )? element-name-text(e)  
  
element-name-text (e : Element) =  
  NAME(e.name) | NAME(e.humanId)  
  
annotated-element-text (e : Element) =  
  element-text(e) element-graphic(e.ownedAnnotation) *  
  
element-graphic (e : Element) =  
  element-symbol(e) element-graphic(e.ownedRelationship) *  
  
element-text (e : Element) = ...  
  
element-symbol (e : Element) = ...
```

Generic textual elements used within the SysML graphical notation include:

- Identifying an Element by its `identifier` (UUID), `aliasId` (including `humanId`) and/or name.
- Referencing an Element using a qualified name.

The specific textual and symbolic representation for an Element, as used within graphical diagrams, are specified for each kind of Element in following subclauses. In general,

- The *annotated* text for an Element is the basic Element text, optionally with the graphical representation of some or all of its ownedAnnotations (see 7.2.2).
- The full *graphical representation* of an Element is the Element symbol, optionally with the graphical representation of some or all of its ownedRelationships.

7.2.1.3 Basic Elements Abstract Syntax

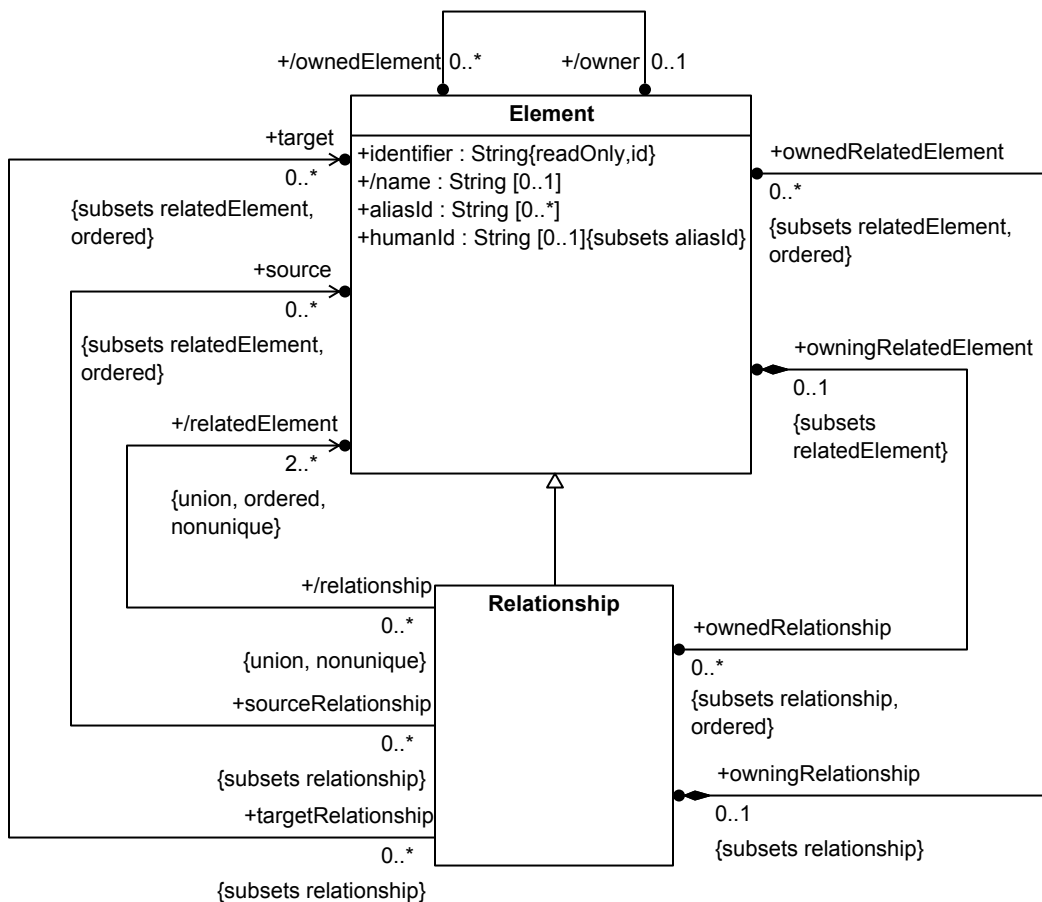


Figure 2. Elements

7.2.2 Annotations

7.2.2.1 Annotations Overview

An *AnnotatingElement* is an *Element* that is used to provide additional information on other elements. An *Annotation* is a *Relationship* between an annotating element and an element that is being described. An annotated element can annotate multiple elements, and each element can have multiple annotations.

A *Comment* is one kind of *AnnotatingElement* that is used to provide textual descriptions about other elements. The comments about an element need not be owned by that element, but an element can contain distinguished documentation comments that are specifically used to document it. Comments can be named.

A TextualRepresentation is an AnnotatingElement whose textual body can be represented in another language. In particular, if the named language is machine-parsable, then the body text should be legal input text as defined for that language. In particular, annotating a SysML model element with a textual annotation in a language other than SysML can be used as a semantically "opaque" element specified in the other language.

Submission Note. It is expected that additional kinds of AnnotatingElements will be defined in the revised submission, such as for providing additional metadata for an Element. It is also expected that there will be a way for a modeler to add new kinds of AnnotatingElements as part of the language extension mechanism.

7.2.2.2 Annotations Concrete Syntax

7.2.2.2.1 Annotations Textual Notation

7.2.2.2.1.1 Comments

```
Comment (m : Membership, e : Element) : Comment =
  ( 'comment' Identification(this, m)
    'about' annotation += Annotation
    { ownedRelationship += annotation }
    ( ',' annotation += Annotation
      { ownedRelationship += annotation } ) *
  | ( 'comment' Identification(this, m) ) ?
    annotation += ElementAnnotation(e)
    { ownedRelationship += annotation } )
  body = REGULAR_COMMENT

Annotation : Annotation =
  annotatedElement = [Element | QualifiedId]

ElementAnnotation ( e : Element ) : Annotation =
  { annotatedElement = e }
```

The SysML textual concrete syntax for Comments is the same as the KerML notation (see [KerML, 7.2.3.2.1]).

7.2.2.2.1.2 Documentation

```
OwnedDocumentation : Documentation =
  documentingElement = DocumentationComment

DocumentationComment : Comment =
  'doc' ( 'id' humanId = Name ) ? body = REGULAR_COMMENT

PrefixDocumentation : Documentation =
  documentingElement = PrefixDocumentationComment

PrefixDocumentationComment : Comment =
  ( 'doc' ( 'id' humanId = Name ) ? ) ? body = DOCUMENTATION_COMMENT
```

The SysML textual concrete syntax for Documentation is the same as the KerML notation (see [KerML, 7.2.3.2.2]).

7.2.2.2.1.3 Textual Representation

```
TextualRepresentation (m : Membership) : TextualRepresentation =  
  ( 'rep' Identification(this, m)  
    'about' annotation += Annotation  
  | ( 'rep' Identification(this, m) )?  
    ElementAnnotation(e)  
  )  
  'language' language = STRING_VALUE  
  body = ML_COMMENT
```

The SysML textual concrete syntax for TextualRepresentations is the same as that of KerML (see [KerML, 7.2.3.2.3]).

In addition to the standard TextualNotation `language` names defined for KerML, a conformant SysML modeling tool shall also recognize the language name "sysml" (ignoring case), in which case the `body` text of the TextualAnnotation shall be a legal representation of the represented element in the SysML textual concrete syntax as defined in this specification.

7.2.2.2.2 Annotations Graphical Notation

```
element-graphic (a : Annotation) =
    comment-graphic(a)
    | documentation-graphic(a)
    | textual-representation-graphic(a)

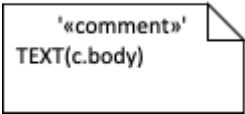
comment-graphic (a : Annotation) =
    ( &element(a.annotatedElement) annotation-symbol ) *
    comment-symbol(a.annotatingElement)

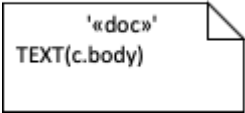
documentation-graphic (d : Documentation ) =
    &element(d.documentedElement) annotationSymbol
    documentation-symbol(d.documentingComment)

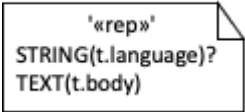
textual-representation-graphic (a : Annotation) =
    &element(a.annotatedElement) annotation-symbol
    textual-representation-symbol(a.annotatingElement)

element (e : Element) =
    element-text(e) | element-symbol(e)

annotation-symbol =
    -----

comment-symbol (c : Comment) =
    

documentation-symbol (c : Comment) =
    

textual-representation-symbol (t : TextualRepresentation) =
    
```

Note. The graphical representation of an Annotation may be used to annotate both textual and symbolic representations of an element within a larger graphical diagram.

7.2.2.3 Annotations Abstract Syntax

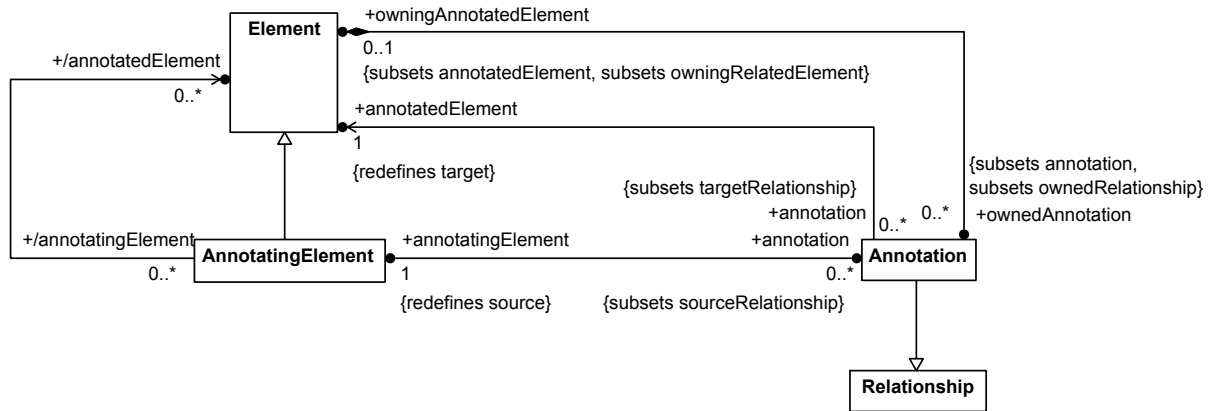


Figure 3. Annotation

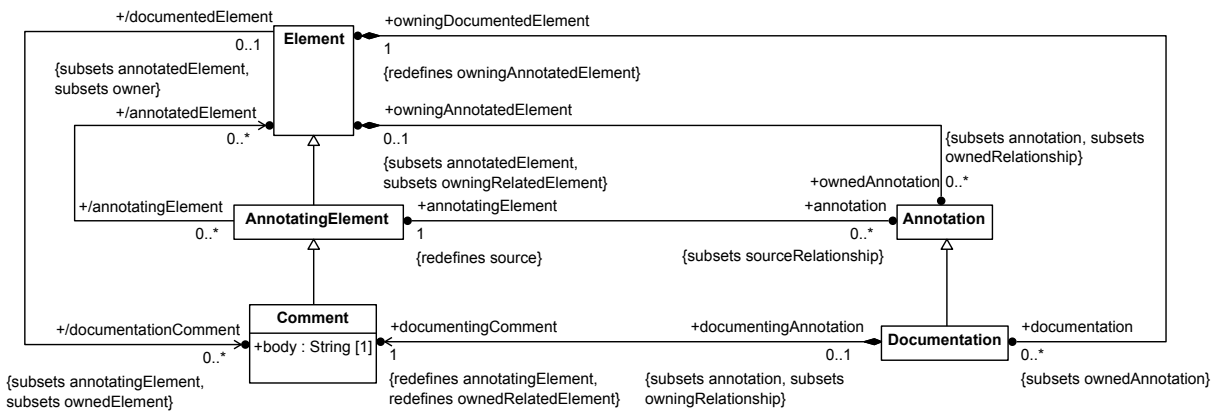


Figure 4. Comments

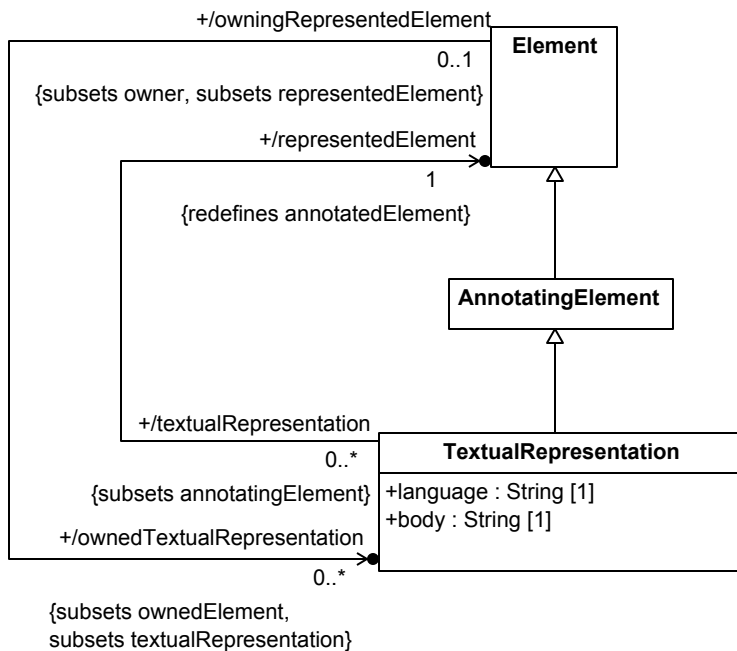


Figure 5. Textual Representation

7.2.3 Packages

7.2.3.1 Packages Overview

A Package is a kind of Element that is used as a container for other elements to organize the model. The elements contained in a package are referred to as member elements. Membership is a kind of Relationship that relates a package to its members. The members can be either owned members or unowned members. Specific semantics apply to owned members that include deletion semantics. Deletion semantics specify that when a package is deleted, all of its owned members are also deleted. A package can import another package using an import relationship. This enables the importing package to refer to the members of the imported package directly, without having to qualify the member names with the name of the imported package. The imported members are unowned members of the importing package.

7.2.3.2 Packages Concrete Syntax

7.2.3.2.1 Packages Textual Notation

7.2.3.2.1.1 Packages

```
RootPackage : Package =
    PackagedElement(this) *

Package (m : Membership) : Package =
    PackageDeclaration(this, m) PackageBody(this)

PackageDeclaration (m : Membership, p : Package) : Package =
    'package' Identification(p, m)

PackageBody (p : Package) =
    ';' | '{' PackageBodyElement(p) * '}'

PackageBodyElement (p : Package) =
    p.documentation += OwnedDocumentation
    | p.ownedMembership += PackageMember(p)
    | p.ownedImport += PackageImport

PackageMember (p : Package) : Membership
    ( documentation += PrefixDocumentation ) *
    ( visibility = BasicVisibilityIndicator ) ?
    ( NonUsagePackageMember(this, p)
    | UsagePackageMember(this) )

NonUsagePackageMember (m : Membership, p : Package) =
    m.ownedMemberElement = DefinitionElement(m, p)
    | ( 'alias' | 'import' ) m.memberElement = [Qualified Name]
    ( 'as' m.memberName = NAME ) ? ';'

UsagePackageMember (m : Membership) =
    m.ownedMemberElement = UsageElement(m)

PackageImport : Import =
    ( documentation += PrefixDocumentation ) *
    ( visibility = BasicVisibilityIndicator ) ?
    'import' importedPackage = [Qualified Name] ':' '*' ';'

BasicVisibilityIndicator : VisibilityKind =
    'public' | 'private'
```

The SysML textual concrete syntax for a Package is the same as the KerML textual notation (see [KerML, 7.2.4.1, 7.4.2.2]), except that only legal SysML Elements are allowed in a SysML Package.

As in KerML, the declaration of a root Package is implicit and no identification of it is provided in the SysML textual notation. Instead, the body of a root package (i.e., a SysML "model") is given simply by the list of representations of its top-level Elements, typically in a single textual document.

The KerML rules for name resolution shall also apply for the SysML textual concrete syntax (see [KerML, 7.2.4.2.4]).

7.2.3.2.1.2 Package Elements

```
DefinitionElement (m : Membership) : Element =
    Package(m)
  | Comment(m, p)
  | TextualRepresentation(m, p)
  | Dependency(m)
  | AttributeDefinition(m)
  | ItemDefinition(m)
  | PartDefinition(m)
  | IndividualDefinition(m)
  | ConnectionDefinition(m)
  | InterfaceDefinition(m)
  | PortDefinition(m)
  | ActionDefinition(m)
  | CalculationDefinition(m)
  | StateDefinition(m)
  | ConstraintDefinition(m)
  | RequirementDefinition(m)
  | CaseDefinition(m)
  | AnalysisCaseDefinition(m)
  | VerificationCaseDefinition(m)
  | ViewDefinition(m)
  | ViewpointDefinition(m)
  | RenderingDefinition(m)

UsageElement (m : Membership) : Usage =
    AttributeUsage(m)
  | ItemUsage(m)
  | PartUsage(m)
  | IndividualUsage(m)
  | TimeSliceUsage(m)
  | SnapshotUsage(m)
  | PortUsage(m)
  | ConnectionUsage(m)
  | Connector(m)
  | InterfaceUsage(m)
  | ActionUsage(m)
  | CalculationUsage(m)
  | StateUsage(m)
  | ConstraintUsage(m)
  | RequirementUsage(m)
  | CaseUsage(m)
  | AnalysisCaseUsage(m)
  | VerificationCaseUsage(m)
  | ViewUsage(m)
  | ViewpointUsage(m)
  | RenderingUsage(m)
```

A Package body can contain other Packages, Comments (see [Clause](#)) and SysML Definitions and Usages (see [7.4](#)).

7.2.3.2.2 Packages Graphical Notation

7.2.3.2.2.1 Packages

```

element-text (p : Package) =
    PackageDeclaration(p, p.owningMembership)

```

```

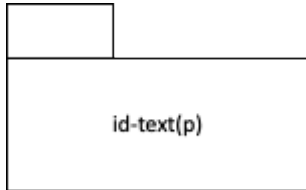
element-symbol (p : Package) =
    package-no-body-symbol (p)
    | package-text-body-symbol (p)
    | package-graphic-body-symbol (p)

```

```

package-no-body-symbol (p : Package) =

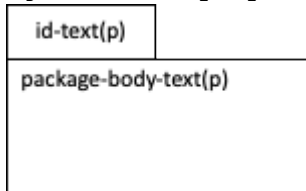
```



```

package-text-body-symbol (p : Package) =

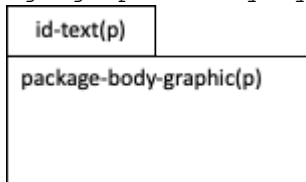
```



```

package-graphic-body-symbol (p : Package) =

```



```

package-body-text (p : Package) =
    ( package-membership-text (p.ownedMembership)
    | package-alias-text (p.ownedMembership)
    | package-import-text (p.ownedImport) ) *

```

```

package-membership-text (m : Membership) =
    visibility-text(m.visibility)? annotated-element-text(m.ownedMemberElement)

```

```

package-alias-text (m : Membership) =
    visibility-text(m.visibility)? ( 'alias' | 'import' )
    qualified-name-text(m.memberElement) ( 'as' NAME(m.memberName) )?
    element-graphic(i.ownedAnnotation) *

```

```

package-import-text(i : Import) =
    visibility-text(i.visibility)? 'import'
    qualified-name-text(i.importedPackage) '::<' '*'
    element-graphic(i.ownedAnnotation) *

```

```

package-body-graphic (p : Package) =

```

```
element-graphic(m.ownedMember) *
```

7.2.3.2.2 Memberships

```

element-symbol (m : Membership) =
  package-membership-symbol(m) | package-alias-symbol(m)

package-membership-symbol (m : Membership) =
  &element-symbol (m.membershipOwningPackage)  $\oplus$   $\xrightarrow{\text{visibility-text}(m.\text{visibility})?}$  &element-symbol (m.ownedMemberElement)

package-alias-symbol (m : Membership) =
  &element-symbol (m.membershipOwningPackage)  $\xrightarrow[\text{NAME}(m.\text{memberName})?]{\text{visibility-text}(i.\text{visibility})? \text{'«alias»'}}$  &element-symbol (m.memberElement)

element-symbol (i : Import) =
  &element-symbol (i.importOwningPackage)  $\xrightarrow[\text{visibility-text}(i.\text{visibility})? \text{'«import»'}]{}$  &element-symbol (i.importedPackage)

visibility-text (VisibilityKind::public) = '+' | 'public'
visibility-text (VisibilityKind::private) = '-' | 'private'

```

7.2.3.3 Packages Abstract Syntax

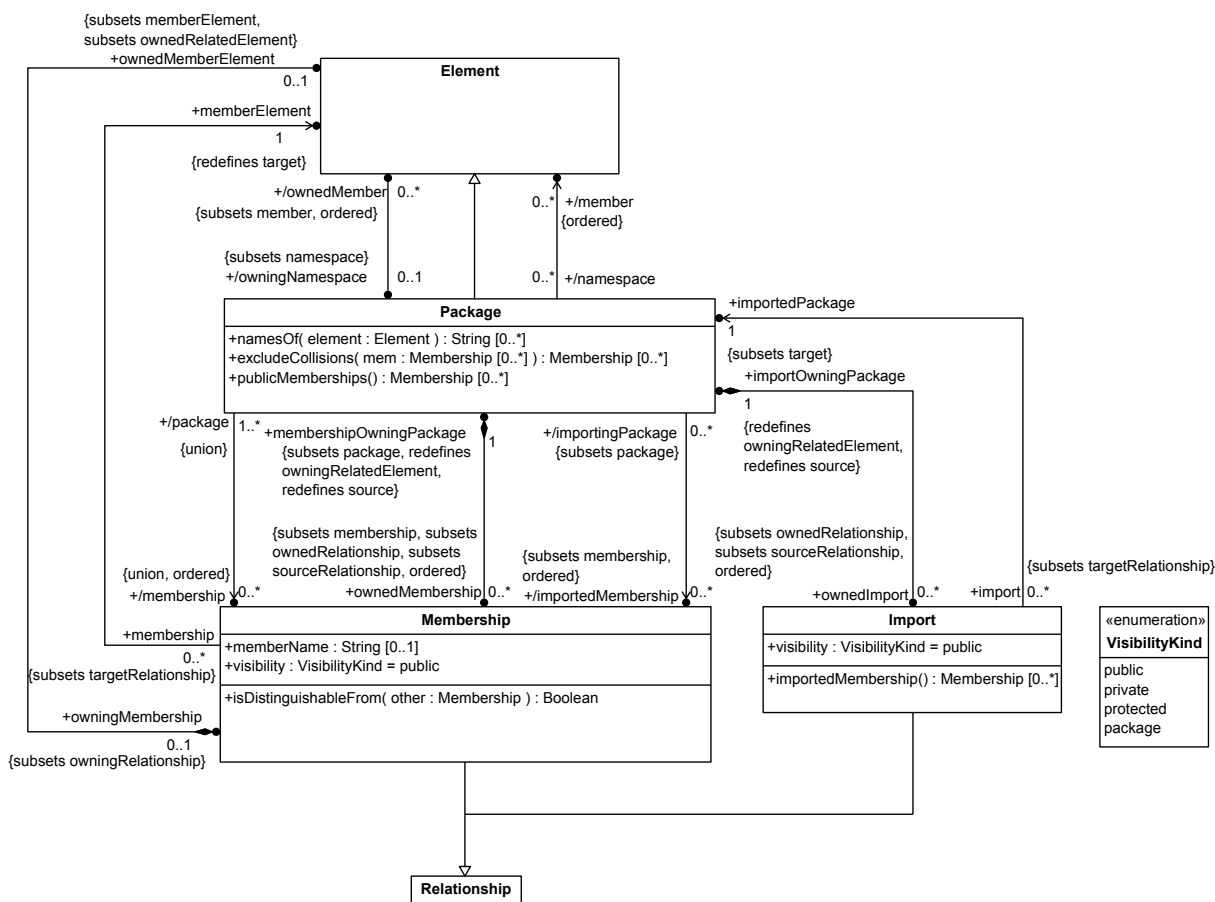


Figure 6. Packages

7.2.4 Types

7.2.4.1 Types Overview

Types

Types are used to classify things in the universe being modeled, which are called the instances of the type. There are two kinds of types: classifiers, which classify individual things (see [7.2.5](#)), and features, which classify how things are related (see [7.2.6](#)). In SysML, definitions are classifiers, while usages are features (see [7.4](#)).

A type is also a kind of package and, therefore, can contain members (see [7.2.3](#)). Feature membership is a special kind of membership relationship between a type and its features. Each feature of a type relates the featuring type to other types, mapping from instances of the featuring type to zero or more values of the feature. In this way, a features of type can be used to model properties of the instances classified by that type, whose values are instances classified by the types of the those features.

Since a feature is itself a kind of type, a feature can have its own nested features. This means that the relation defined by a feature is relative to the context of the hierarchy of features in which it is nested.

In KerML, any kind of type can have a multiplicity restricting the cardinality of its instances. However, in SysML multiplicity is only used on features (see [7.2.6](#)), except implicitly to restrict the cardinality for individual definitions (see [7.11](#)).

Generalization

Generalization is a relationship between a specific type and a general one, indicating that all instances of the specific Type are instances of the general one. This means instances of the specific Type have all the features of the general ones, referred to syntactically as *inheriting* features from general to specific Types. It is allowable for generalization relationships to form cycles, which means all the types in the cycle have the same instances.

There are specialized kinds of generalization for classifiers and features, and these are the only kinds used in SysML (see [7.2.5](#) and [7.2.6](#)).

Conjugation

Conjugation is a relationship between two Types in which the conjugated type inherits features from the original type, except that the direction of input and output features is reversed. Features no direction are inherited without change. In SysML, conjugation is only used for ports (see [7.8](#)).

7.2.4.2 Types Concrete Syntax

7.2.4.2.1 Types Textual Notation

7.2.4.2.1.1 Types

```
TypeBody (t : Type) :  
    ';' | '{' TypeBodyElement(t) * '}'  
  
TypeBodyElement (t : Type) : Type =  
    t.documentation += OwnedDocumentation  
    t.ownedMembership += NonFeatureTypeMember(t)  
    | t.ownedFeatureMembership += FeatureTypeMember  
    | t.ownedImport += PackageImport  
  
NonFeatureTypeMember (t : Type) : Membership =  
    TypeMemberPrefix(this) DefinitionElement(this, t)  
  
FeatureTypeMember : FeatureMembership =  
    FeatureMember | EndFeatureMember  
  
TypeMemberPrefix (m : Membership) :  
    ( m.ownedRelationship += PrefixAnnotation ) *  
    ( m.visibility = VisibilityIndicator ) ?  
  
VisibilityIndicator : VisibilityKind =  
    PackageVisibilityIndicator | 'protected'
```

SysML does not provide any concrete syntax for generic Types or Generalizations that are not instances of a more specialized metaclass. While the Type and Generalization metaclasses are not abstract in the KerML abstract syntax, they shall not be directly instantiated in a SysML model.

The common syntax defined above is used in the definition of the concrete syntax of the bodies of BindingConnectors (see [7.2.8](#)), Successions (see [7.2.8](#)) and ItemFlows (see [7.2.10](#)), and in part for SysML Definitions and Usages (see [7.4](#)).

Conjugation is used implicitly in the context of the syntax of Ports in SysML (see [7.8](#)). They shall not be used in SysML outside of this context.

7.2.4.2.1.2 Feature Membership

```
FeatureMember : FeatureMembership =  
    TypeMemberPrefix(this) direction = FeatureDirection  
    ownedMemberFeature = FeatureElement(this)  
  
EndFeatureMember : EndFeatureMembership =  
    TypeMemberPrefix(this) 'end' direction = FeatureDirection  
    ownedMemberFeature = FeatureElement(this)  
  
FeatureDirection : FeatureDirectionKind =  
    'in' | 'out' | 'inout'  
  
FeatureElement (m : Membership) : Feature =  
    UsageElement(m)  
    | BindingConnector(m)  
    | Succession(m)  
    | ItemFlow(m)  
    | SuccessionItemFlow(m)
```

7.2.4.2.2 Types Graphical Notation

7.2.4.2.2.1 Types

```
element-text (t : Type) =  
    variation-keyword(t)? abstract-keyword(t)? ref-keyword(t)?  
    kind-keyword(t) type-decl-text(t)  
  
variation-keyword (t : Type) = none  
  
abstract-keyword (t : Type) =  
    'abstract'(t.isAbstract)  
  
kind-keyword (t : Type) = ...  
  
ref-keyword (t : Type) = none  
  
type-decl-text (t : Type) = ...
```

Notes

- A KerML Type cannot in general be a variation. However, SysML Definitions and Usages can, and Type is the common superclass of Definition and Usage (see [7.4](#)). Therefore, it is convenient to provide a placeholder for the **variation** keyword in the general textual representation for a Type, even though this is never used for Types that are not Definitions or Usages.
- The *kind keyword* and *type declaration text* for a Type are specified for specific kinds of Types in following subclauses.

- The **ref** keyword is only applicable for Features (see [7.2.6](#)), but it is convenient to provide a placeholder for it in the general textual representation for a Type.

7.2.4.2.2.2 Feature Membership

```
package-membership-text (m : FeatureMembership) =
  visibility-text(m.visibility)? end-keyword(m)? direction-keyword(m)?
  annotated-element-text(m.ownedMemberElement)
```

```
visibility-text (VisibilityKind::protected) = '#' | 'protected'
Note: The visibility 'protected' is allowed only for members of Types.
```

```
end-keyword (m : FeatureMembership) = none
end-keyword (m : EndFeatureMembership) = 'end'
```

```
direction-keyword (m : Membership) = direction-text(m.direction)
direction-text (FeatureDirectionKind::in) = 'in'
direction-text (FeatureDirectionKind::out) = 'out'
direction-text (FeatureDirectionKind::inout) = 'inout'
direction-keyword (m : ReturnParameterMembership) = 'return'
```

```
package-membership-graphic (m : FeatureMembership) =
  feature-membership-graphic(m, m.isComposite)
```

```
feature-membership-graphic (m : FeatureMembership, true) =
  &element-symbol (m.owningType) ◆ visibility-text(m.visibility)? &element-symbol (m.ownedMemberFeature)
```

```
feature-membership-graphic (m : FeatureMembership, false) =
  &element-symbol (m.owningType) ◇ visibility-text(m.visibility)? &element-symbol (m.ownedMemberFeature)
```


7.2.4.3 Types Abstract Syntax

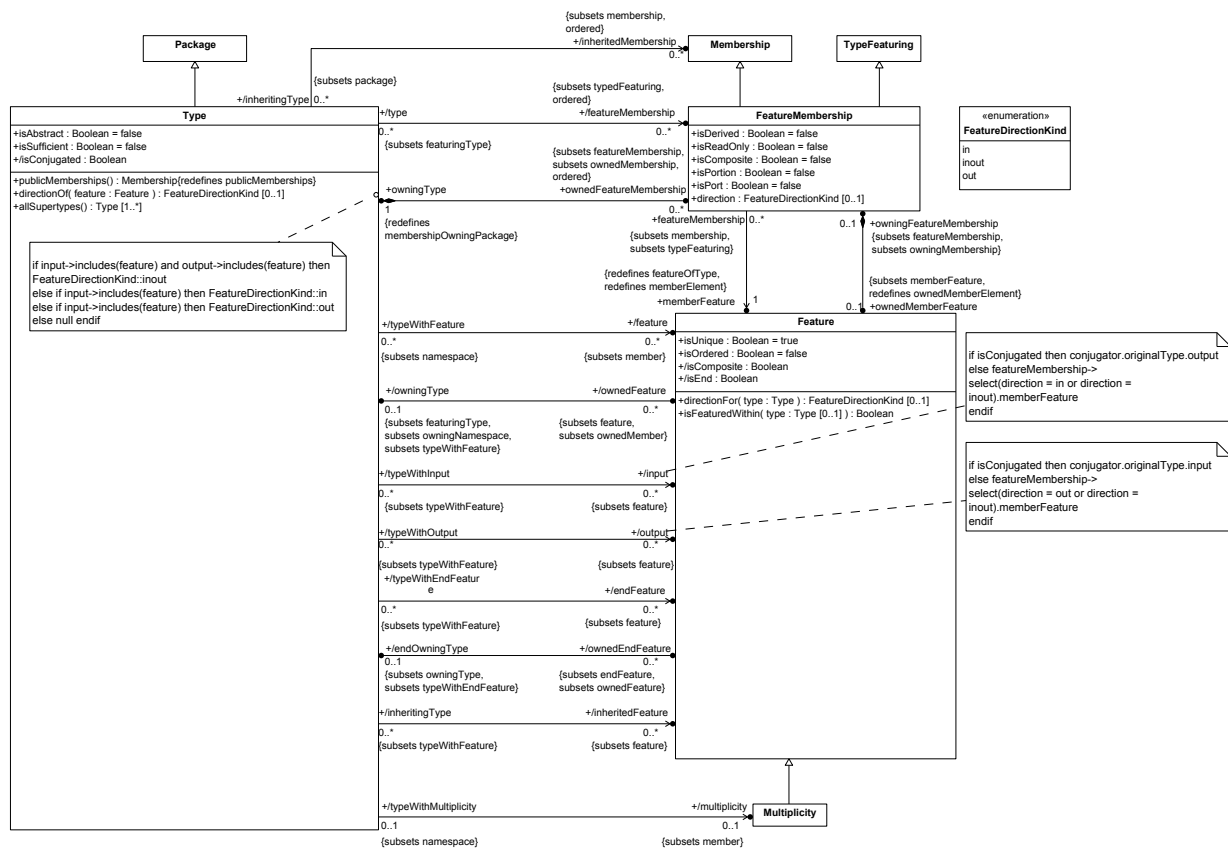


Figure 7. Types

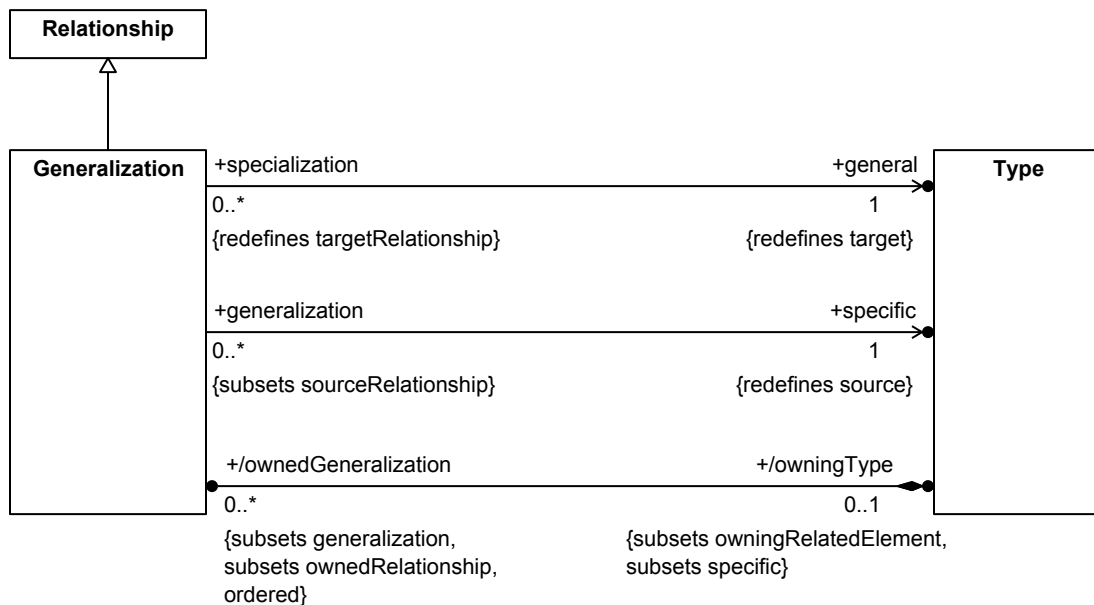


Figure 8. Generalization

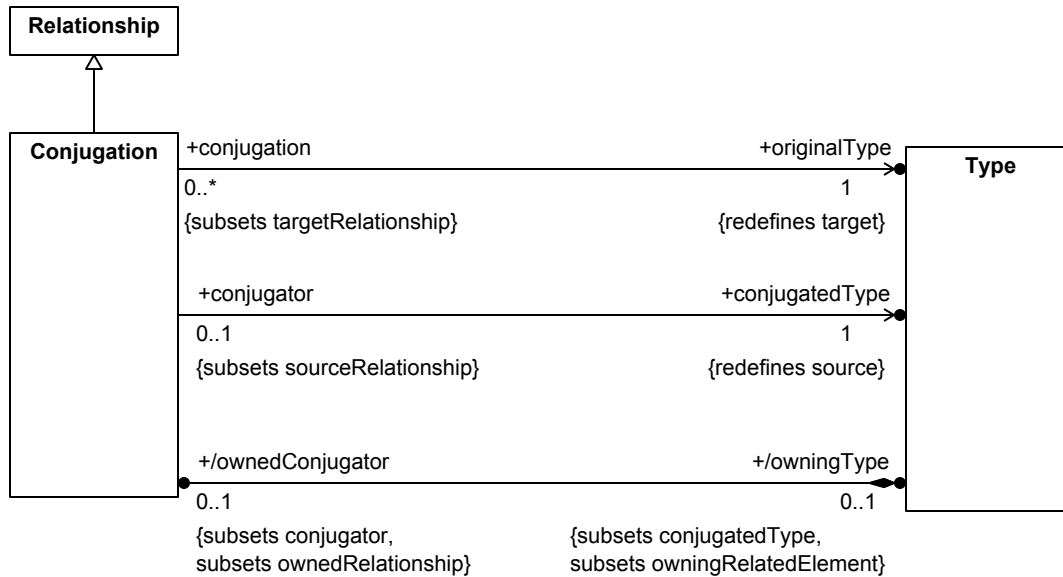


Figure 9. Conjugation

7.2.5 Classifiers

7.2.5.1 Classifiers Overview

Classifiers are types that classify things in the modeled universe, regardless of how features related them. In SysML, all definitions are classifiers (see [7.4](#)).

Superclassing is a kind of generalization between classifiers. SysML allows superclassing between definitions.

Data types are classifiers that classify data values, that is, values that do not change over time. Data values are generally distinguishable when they differ in how they are related to other things. However, data values for some data types are directly identified (enumerated), in which case they are distinguishable regardless of their relationship to other things, including the primitive types defined in the Kernel Model Library *ScalarValues* package (see [KerML, 8.10]), and any subtypes of those. In SysML, attribute definitions are data types (see [7.5](#)),

Classes are classifiers that classify objects. Every object is considered to occur over some period of time, and possibly also over some extent in space. The relationships that an object has with other things in the modeled universe (via features) may vary over time and space, particularly as the result of the object being acted on by the performance of a Behavior (see [7.2.9](#)). That is, a single Feature may be interpreted to map different portions of the temporal and spacial extent of an object to different results. In SysML, item definitions are classes (see [7.6](#)).

7.2.5.2 Classifiers Concrete Syntax

7.2.5.2.1 Classifiers Textual Notation

```

SuperclassingPart (c : Classifier) =
    ( '>' | 'specializes' ) c.ownedSuperclassing += OwnedSuperclassing
    ( ',' c.ownedSuperclassing += OwnedSuperclassing ) *

OwnedSuperclassing : Superclassing =
    superclass = [Qualified Name]
  
```

SysML only provides concrete syntax for classifiers that are kinds of definitions (see [7.4](#)). The notation for Superclassing is consistent with that of KerML.

7.2.5.2.1.1 Classifiers

SysML only provides concrete syntax for classifiers that are kinds of definitions (see [7.4](#)).

7.2.5.2.1.2 Superclassing

```
SuperclassingPart (c : Classifier) =
  ( '>' | 'specializes' ) c.ownedSuperclassing += OwnedSuperclassing
  ( ',' c.ownedSuperclassing += OwnedSuperclassing ) *

OwnedSuperclassing : Superclassing =
  superclass = [Qualified Name]
```

7.2.5.2.2 Classifiers Graphical Notation

7.2.5.2.2.1 Classifiers

SysML only provides concrete syntax for classifiers that are kinds of definitions (see [7.4](#)).

7.2.5.2.2.2 Superclassing

```
element-symbol (s : Superclassing) =
  &element-symbol (s.subclass) —————> &element-symbol (s.superclass)
```

7.2.5.3 Classifiers Abstract Syntax

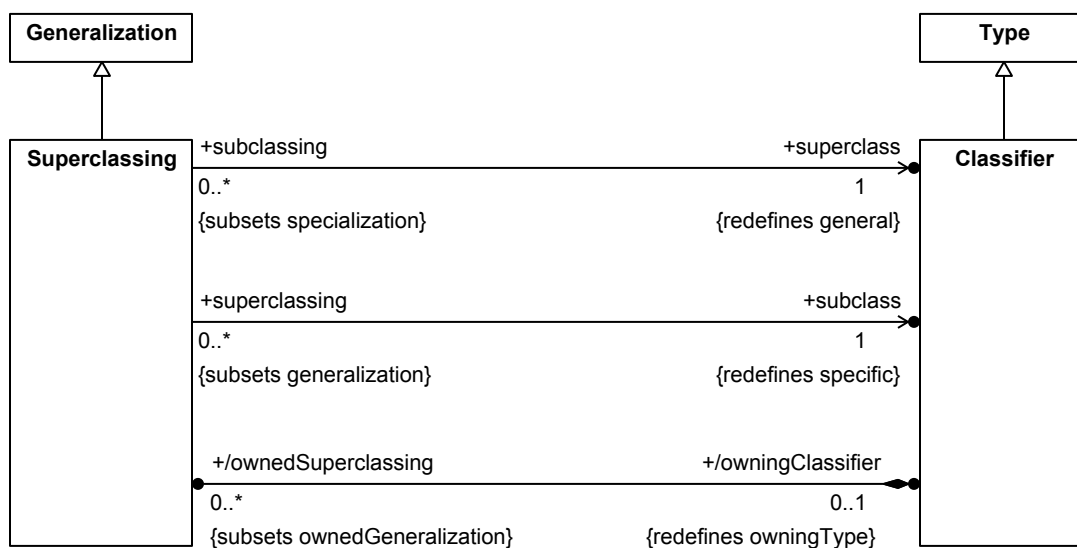


Figure 10. Classifiers

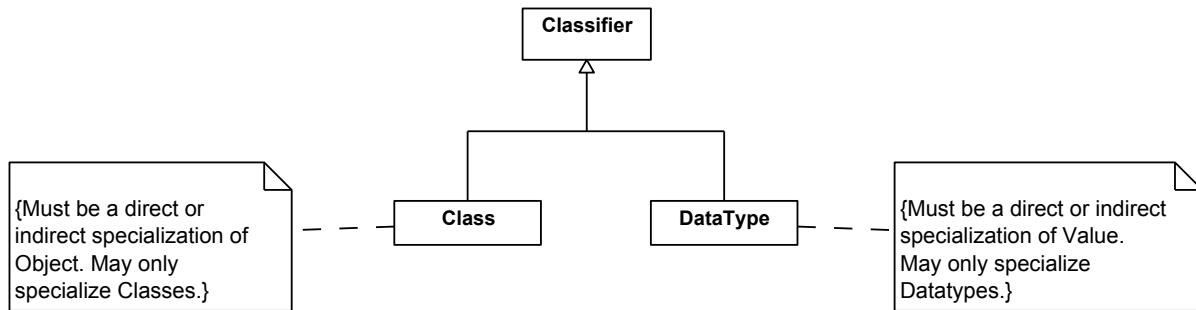


Figure 11. Classification

7.2.6 Features

7.2.6.1 Features Overview

A feature is a type that classifies how things in the modeled universe are related, including by chains of relationships. Relations between things can themselves be treated as things, allowing relations between relations (recurring as many times as needed). In SysML, all usages are features.

Multiplicity

A feature may have a multiplicity that constrains its cardinality, that is, the allowed number of values it may have for any instance of its featuring type. The multiplicity is specified as a range, giving the lower and upper bound expressions that are evaluated to determine the lower and upper bounds of the specified range. The lower bound must be a natural number, while the upper bound must be an unlimited natural number, that is, a natural number of the unbounded value *. An upper bound value of * indicates that the range is unbounded, that is, it includes all numbers greater than or equal to the lower bound value. If a lower bound is not given, then the lower bound is taken to be the same as the upper bound, unless the upper bound is *, in which case the lower bound is taken to be 0.

Submission Note. Allowing more kinds of Multiplicities than just ranges (e.g., sets of cardinalities like [2, 4, 6]) will be considered for the revised submission.

Feature Typing

Feature typing is a kind of generalization between a feature and a type. Feature typing is used to declare the types that values of the typed feature must have.

Subsetting

Subsetting is a kind of generalization between two features, in which the values of the subsetting feature are a subset of the values of the subsetted feature. The subsetting feature inherits the feature typings of the subsetted feature, but may specify additional feature typings, whose types further constraint the values of the subsetting feature. The subsetting feature also by default inherits the multiplicity of the subsetted feature, but may further constraint that multiplicity.

Redefinition

Redefinition is a kind of subsetting in which the redefined feature is a feature of a direct or indirect generalization of the owning type of the redefining feature that would otherwise be inherited. In this case, the otherwise inheritable redefined feature is not inherited into the namespace of the owning type and is, instead, replaced by the redefining feature. As for regular subsetting, the redefined feature may further restrict the types and/or the multiplicity of the redefined feature.

Feature Values

A feature value is a special kind of membership that relates a feature to an expression (see [7.2.12](#)). A feature can have at most one feature value. The result of the expression is bound to the feature itself (see [7.2.8](#) on binding connectors), effectively asserting that the values of the feature are always determined by the result of the given Expression.

7.2.6.2 Features Concrete Syntax

7.2.6.2.1 Features Textual Notation

7.2.6.2.1.1 Features

```
FeatureDeclaration (f : Feature, m : Membership) =
    Identification(f, m) FeatureSpecializationPart(f)?

FeatureSpecializationPart (f : Feature) =
    FeatureSpecialization(f)+ MultiplicityPart(f)? FeatureSpecialization(f)*
    | MultiplicityPart(f) FeatureSpecialization(f)*

MultiplicityPart (f : Feature) =
    f.ownedMembership += MultiplicityMember
    ( f.isOrdered ?= 'ordered' ( !f.isUnique ?= 'nonunique' )?
    | !f.isUnique ?= 'nonunique' ( isOrdered ?= 'ordered' )? )?

MultiplicityMember : Membership =
    ownedMemberFeature = Multiplicity

Multiplicity : MultiplicityRange =
    '[' ( ownedMembership += LiteralExpressionMember '..' )?
    ownedMembership += LiteralExpressionMember ']'

LiteralExpressionMember : Membership =
    ownedMemberElement = OwnedExpression

ValuePart (f : Feature) =
    '=' f.ownedMembership += FeatureValue

FeatureValue : FeatureValue =
    value = OwnedExpression
```

Other than for certain kinds of Connectors (see [7.2.8](#) and [7.2.10](#)), SysML only provides concrete syntax for Features that are kinds of Usage (see [7.4](#)). The common syntax for Feature declaration defined above is used consistently in the notation for all the specific kinds of Features in SysML.

7.2.6.2.1.2 Feature Specialization

```
FeatureSpecialization (f : Feature) =
    Typings(f) | Subsettings(f) | Redefinitions(f)

Typings (f : Feature) =
    TypedBy(f) ( ',' f.ownedTyping += OwnedFeatureTyping )*

TypedBy (f : Feature) =
    ( ':' | 'defined' 'by' ) f.ownedTyping += OwnedFeatureTyping

OwnedFeatureTyping : FeatureTyping =
    type = [QualifiedName]

Subsettings (f : Feature) =
    Subsets(f) ( ',' f.ownedSubsetting += OwnedSubsetting )*

Subsets (f : Feature) =
    ( ';>' | 'subsets' ) f.ownedSubsetting += OwnedSubsetting

OwnedSubsetting : Subsetting =
    subsettingFeature = [QualifiedName]

Redefinitions (f : Feature) =
    Redefines(f) ( ',' f.ownedRedefinition += OwnedRedefinition )*

Redefines (f : Feature) =
    ( ';>>' | 'redefines' ) ownedRelationship += OwnedRedefinition

OwnedRedefinition : Redefinition =
    redefinedFeature = [QualifiedName]
```

7.2.6.2.2 Features Graphical Notation

7.2.6.2.2.1 Features

```
ref-keyword (f : Feature) =
    ref-text (f.isComposite)

ref-text (true) = none
ref-text (false) = 'ref'

type-dcl-text (f : Feature) =
    FeatureDeclaration(f, f.owningMembership)

feature-label (f : Feature) =
    visibility-keyword(f)? abstract-keyword(f)? ( '«' kind-keyword(f) '»' )?
    id-text(f)? feature-modifier-text(f)*
(Note: As an alternative to using the 'abstract' keyword, the entire label
can be rendered in italics.)

feature-modifier-text (f : Feature) =
    feature-multiplicity-text(f)
| feature-typing-text(f)
| feature-subsetting-text(f)
| feature-redefinition-text(f)
| feature-ordered-text(f)
| feature-nonunique-text(f)

feature-multiplicity-text (f : Feature) =
    element-text(f.multiplicity)

element-text (m : MultiplicityRange) =
    ( OwnedExpression(f.lowerBound) '..' )? OwnedExpression(f.upperBound)

feature-typing-text (f : Feature) = Typings(f)

feature-subsetting-text (f : Feature) = Subsettings(f)

feature-redefinition-text (f : Feature) = Redefinitions(f)

feature-ordering-text (f : Feature) = 'ordered'(f.isOrdered)

feature-nonuniqueness-text (f : Feature) = 'nonunique'(!f.isUnique)
```

7.2.6.2.2 Feature Specialization

```

element-symbol (f : FeatureTyping) =
    &element-symbol (f.typedFeature) —————▶ &element-symbol (f.type)

element-symbol (s : Subsetting) =
    &element-symbol (s.subsettingFeature) —————▶ &element-symbol (s.subsettedFeature)

element-symbol (r : Redefinition) =
    &element-symbol (r.redefiningFeature) —————▶ &element-symbol (r.redefinedFeature)

```

7.2.6.3 Features Abstract Syntax

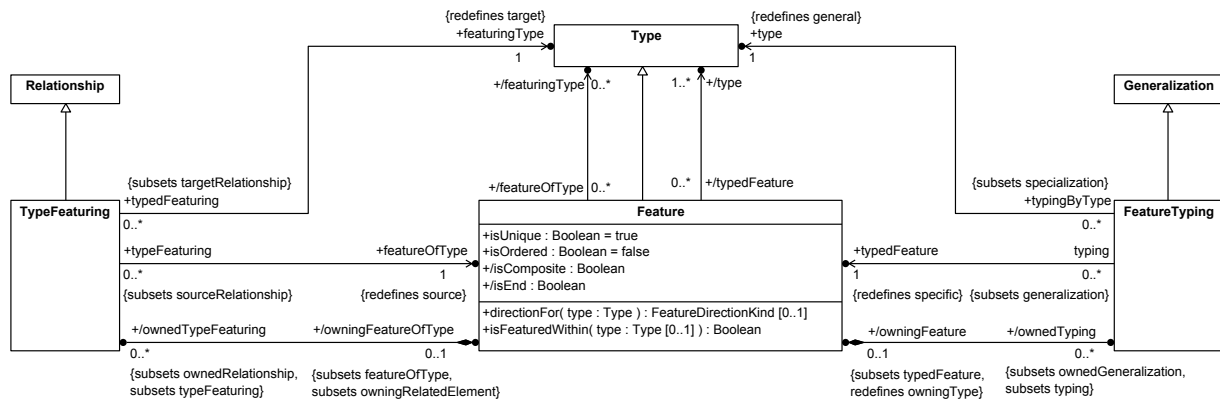


Figure 12. Features

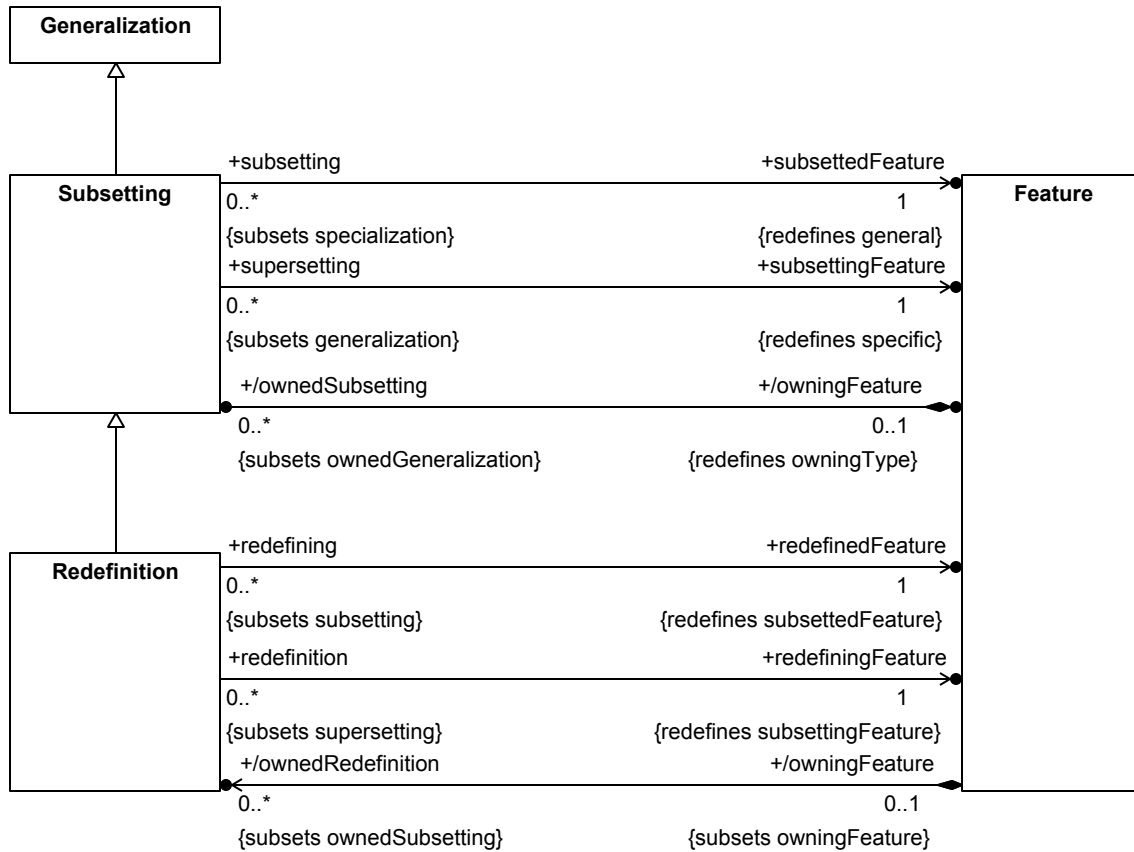


Figure 13. Subsetting

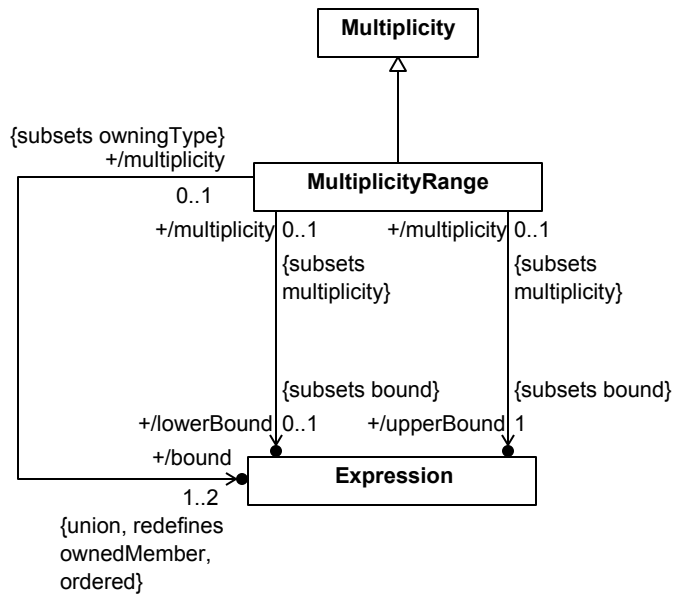


Figure 14. Multiplicities

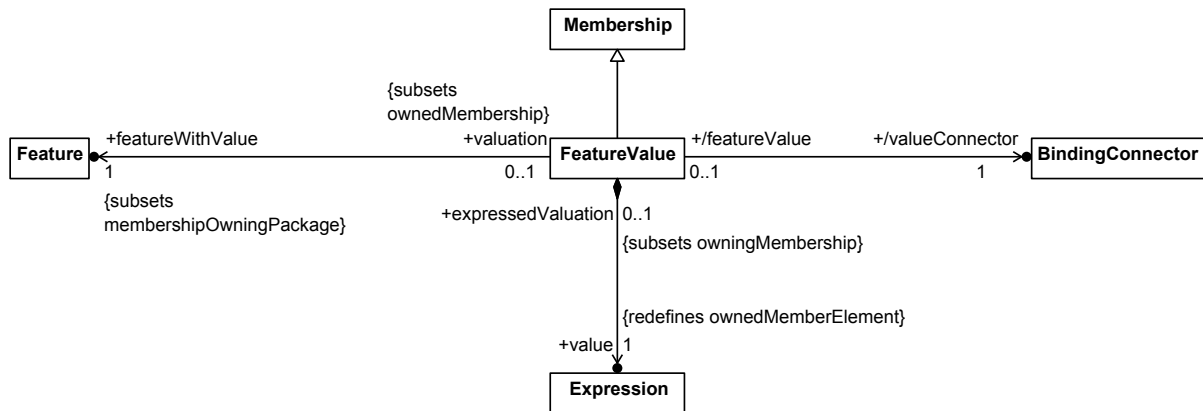


Figure 15. Feature Values

7.2.7 Associations

7.2.7.1 Associations Overview

Associations are classes that classify links between things in the modeled universe, and how they are related by features to those (other) things. SysML connection definitions are associations.

At least two of the owned features of an association must be association ends, related to the association by special end feature memberships. Associations with exactly two association ends classify binary Associations, and they classify binary links.

An association is also a relationship between the types of its association ends. The links of the associations are between instances of these related types.

The features of an association that are not association ends characterize links separately from the linked things. The values of these non-end features can potentially change over time. However, the values of association ends do not change over time (though they can potentially be objects that themselves have features whose values change over time).

7.2.7.2 Associations Concrete Syntax

SysML does not provide any concrete syntax for Associations other than `ConnectionDefinition` (see [7.9](#)) and its specialization `InterfaceDefinition` (see [7.10](#)). The Association metaclass shall not be directly instantiated in a SysML model.

7.2.7.3 Associations Abstract Syntax

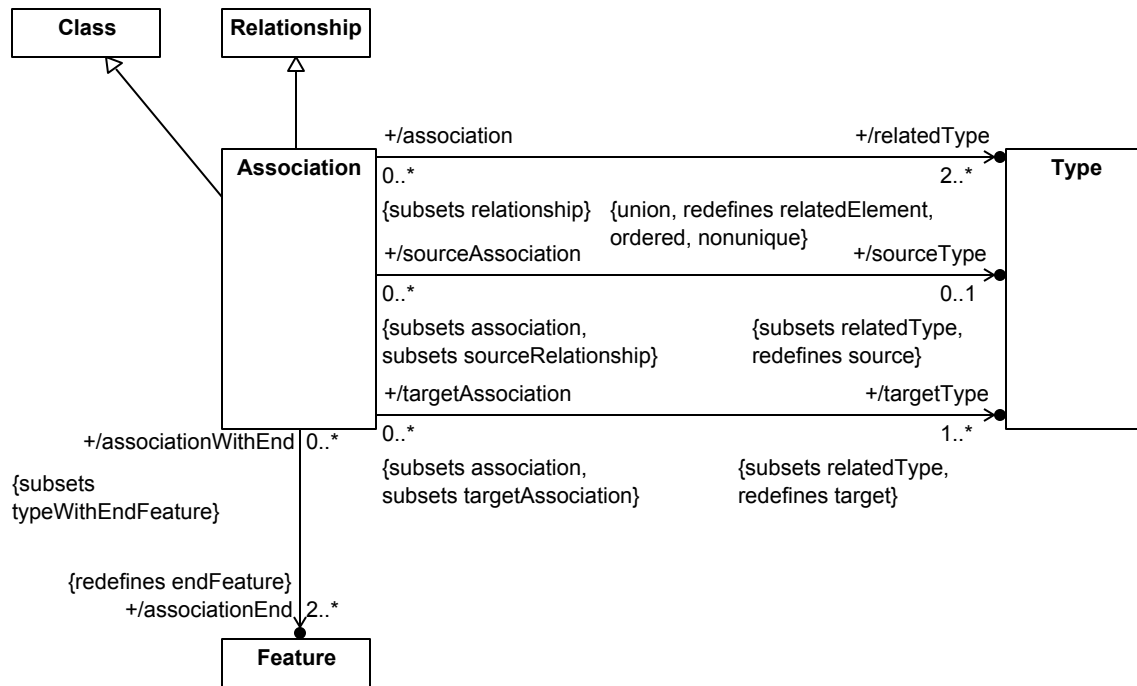


Figure 16. Associations

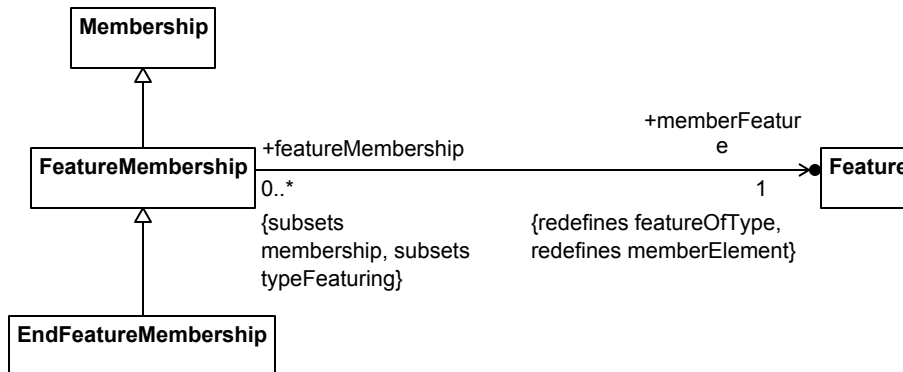


Figure 17. EndFeatureMembership

7.2.8 Connectors

7.2.8.1 Connectors Overview

Connectors

A connector is a kind of feature that is typed by one or more associations. The associations specify the kinds of things that can be linked by the connector, and the connector further restricts those links to be between the values of specific features in its context, known as its related features. A connector is also a relationship between its related features.

All associations typing a connector must have the same number of association ends, which also must be the number of end features of the connector, its connector ends. Each connector end redefines one association end from each of

its types and subsets one of the related features of the connector. Connectors typed by binary associations are called binary connectors.

In SysML, connection usages are connectors between any kinds of items (see [7.9](#)), while interface usages ([7.10](#)) are connectors between port usages.

Binding Connectors

A binding connector is a binary connector that requires its two related features to have the same values. Since data types and classes have disjoint values, a feature typed by data types can only be bound to another feature typed by data types and a feature typed by classes can only be bound to another feature typed by classes. The binding of features typed by classes indicates that the same objects play the roles represented by the related features.

Successions

A succession is a binary connector that requires its two related features to have values that are occurrences that happen completely separated in time, with the first occurrence happening before the second. The linked occurrences can either be objects (instances of Classes, see [7.2.5](#)) or performances (instance of Behaviors, see [7.2.9](#)).

7.2.8.2 Connectors Concrete Syntax

7.2.8.2.1 Connectors Textual Notation

```
ConnectorEndMember : EndFeatureMembership :
    ( memberName = NAME '=>' )? ownedMemberFeature = ConnectorEnd

ConnectorEnd : Feature :
    ownedSubsetting += OwnedSubsetting
    ( ownedMembership += MultiplicityMember )?

BindingConnector (m : Membership) : BindingConnector =
    ( isAbstract ?= 'abstract' )? 'bind'
    BindingConnectorDeclaration(this, m) TypeBody(m)

BindingConnectorDeclaration (c : BindingConnector, m : Membership) =
    ( FeatureDeclaration(c, m)? 'as' )?
    c.ownedFeatureMembership += ConnectorEndMember '='
    c.ownedFeatureMembership += ConnectorEndMember

Succession (m : Membership) : Succession =
    ( isAbstract ?= 'abstract' )? 'succession'
    SuccessionDeclaration(this, m) TypeBody(this)

SuccessionDeclaration (s : Succession, m : Membership) : Succession :
    ( FeatureDeclaration(s, m)? 'first' )?
    s.ownedFeatureMembership += ConnectorEndMember 'then'
    s.ownedFeatureMembership += ConnectorEndMember
```

SysML does not provide concrete syntax for generic Connectors that are not instances of some specialization of Connector. The Connector metaclass shall not be directly instantiated in a SysML model. SysML provides concrete syntax for special kinds of Connectors, including BindingConnectors and Successions, as shown above, and also ItemFlows (see [7.2.10](#)), ConnectionUsages (see [7.9](#)) and InterfaceUsages (see [7.10](#)).

7.2.8.2.1.1 Connectors

```
ConnectorEndMember : EndFeatureMembership :  
    ( memberName = NAME '>' )? ownedMemberFeature = ConnectorEnd  
  
ConnectorEnd : Feature :  
    ownedSubsetting += OwnedSubsetting  
    ( ownedFeatureMembership += MultiplicityMember )?
```

SysML does not provide concrete syntax for generic Connectors that are not instances of some specialization of Connector. The Connector metaclass shall not be directly instantiated in a SysML model. SysML provides concrete syntax for special kinds of Connectors, including BindingConnectors (see [7.2.8.2.1.2](#)), Successions (see [7.2.8.2.1.3](#)), ItemFlows (see [7.2.10](#)), ConnectionUsages (see [7.9](#)), and InterfaceUsages (see [7.10](#)).

7.2.8.2.1.2 Binding Connectors

```
BindingConnector (m : Membership) : BindingConnector =  
    ( isAbstract ?= 'abstract' )? 'bind'  
    BindingConnectorDeclaration(this, m) TypeBody(m)  
  
BindingConnectorDeclaration (c : BindingConnector, m : Membership) =  
    ( FeatureDeclaration(c, m)? 'as' )?  
    c.ownedFeatureMembership += ConnectorEndMember '='  
    c.ownedFeatureMembership += ConnectorEndMember
```

7.2.8.2.1.3 Successions

```
Succession (m : Membership) : Succession =  
    ( isAbstract ?= 'abstract' )? 'succession'  
    SuccessionDeclaration(this, m) TypeBody(this)  
  
SuccessionDeclaration (s : Succession, m : Membership) : Succession :  
    ( FeatureDeclaration(s, m)? 'first' )?  
    s.ownedFeatureMembership += ConnectorEndMember 'then'  
    s.ownedFeatureMembership += ConnectorEndMember
```

7.2.8.2.2 Connectors Graphical Notation

7.2.8.2.2.1 Binding Connectors

```
kind-keyword (c : BindingConnector) = 'bind'

type-dcl-text (c : BindingConnector) =
    BindingConnectorDeclaration(c, c.owningMembership)

element-graphic (c : BindingConnector) =
    &element-symbol (c.relatedElement)  $\xrightarrow{\text{feature-label}(c) \mid '='?}$  &element-symbol (c.relatedElement)
    feature-label (c.connectorEnd) feature-label (c.connectorEnd)
```

Note: The relatedElement and connectorEnd correspond on each end.

7.2.8.2.2.2 Successions

```
kind-keyword (s : Succession) = 'succession'

type-dcl-text (s : Succession) =
    SuccessionDeclaration(s, s.owningMembership)

element-graphic (s : Succession) =
    &element-symbol (s.sourceFeature)  $\xrightarrow{\text{feature-label}(b) \mid '\ll then \gg'?}$  &element-symbol (s.targetFeature)
```

7.2.8.3 Connectors Abstract Syntax

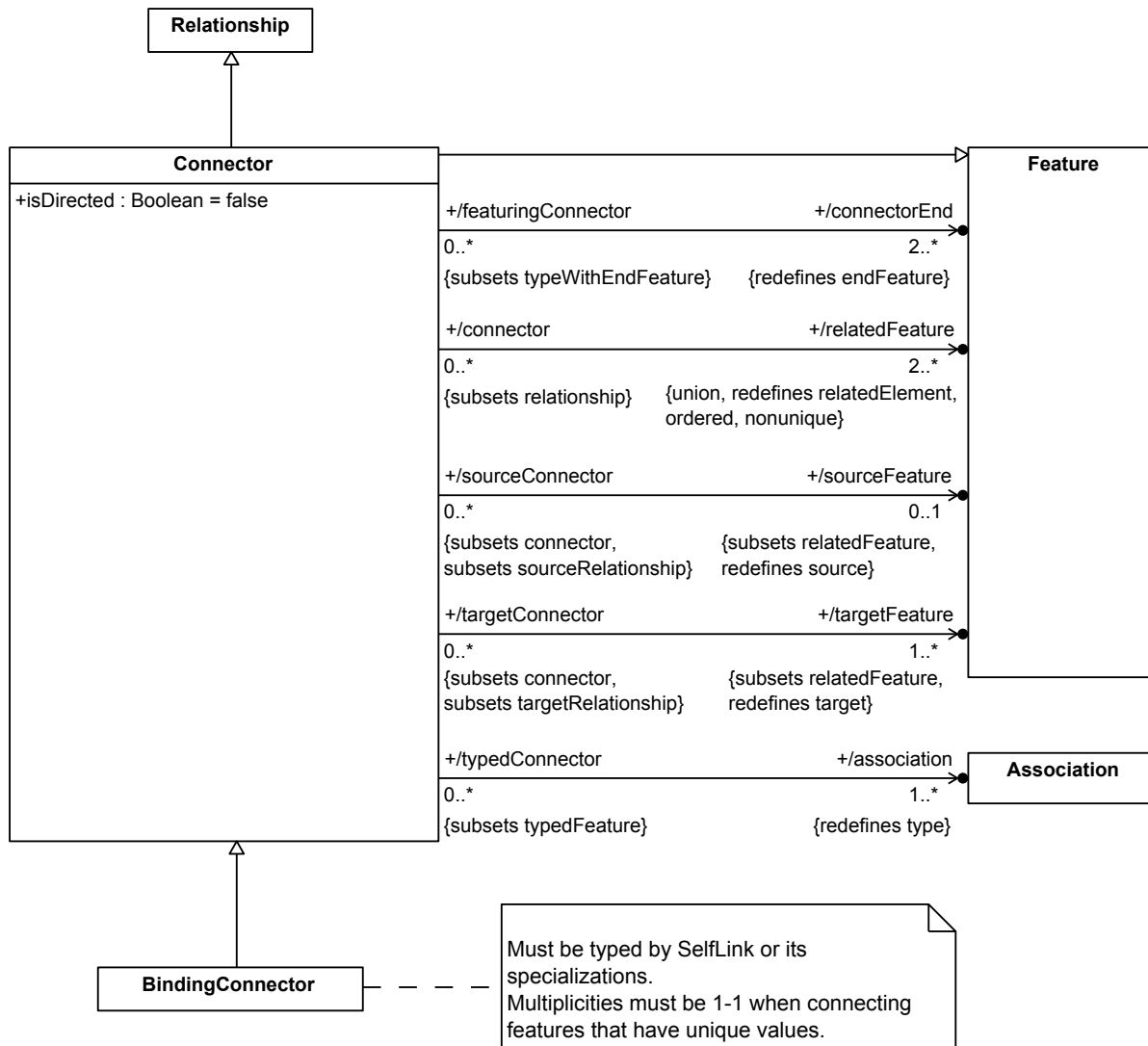


Figure 18. Connectors

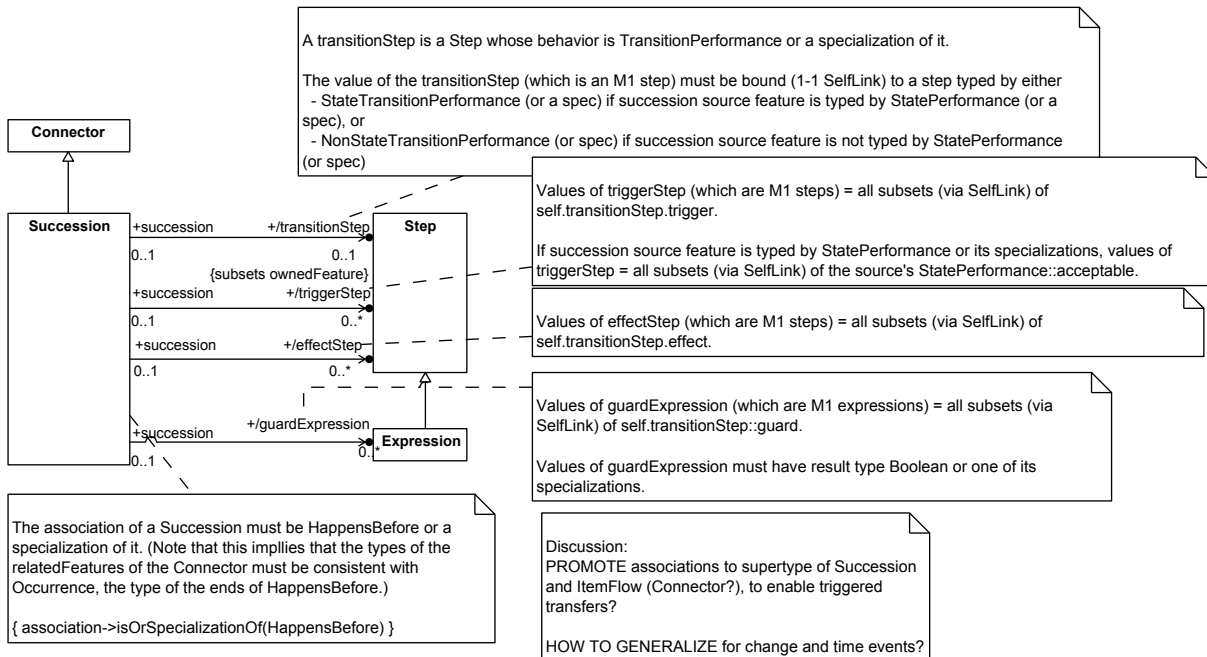


Figure 19. Successions

7.2.9 Behaviors

7.2.9.1 Behaviors Overview

Behaviors

Behaviors are classifiers that classify performances. Performances are occurrences over time that can coordinate the performance of other behaviors and generate effects on objects involved in the performance (including those object's existence and relation to other things), and/or to produce some result before the performance is completed.

A behavior may declare a list of parameters, which are simply distinguished features of the behavior that identify specific information passed into and/or out of the behavior during its performance. A parameter is related to some owning behavior by a special kind of feature membership that is required to have a direction specified, defaulting to "in".

Steps

Steps are features that are typed by behaviors, and, therefore, have performances as their values. The features of a behavior that are steps specify a refinement of the performance of the behavior into performances represented by each of the steps. The steps of a behavior can be connected by successions (see 7.2.8) to order their performances in time and they can be connected by item flows (see 7.2.10) to pass information between their parameters.

Steps inherit the parameters of their behaviors, or they can define their own parameters to augment or redefine those of their behaviors. They can also have nested steps to augment or redefine the steps inherited from their behaviors.

7.2.9.2 Behaviors Concrete Syntax

SysML does not provide any concrete syntax for Behaviors other than ActionDefinitions (see 7.12), ConstraintDefinitions (see 7.15), and their various specializations, nor does it provide any concrete Syntax for Steps other than ItemFlows (see 7.2.10), Expressions (see 7.2.12), ActionUsages (see 7.12), ConstraintUsages (see 7.15), and their various specializations. The Behavior and Step metaclasses shall not be instantiated in SysML models.

7.2.9.3 Behaviors Abstract Syntax

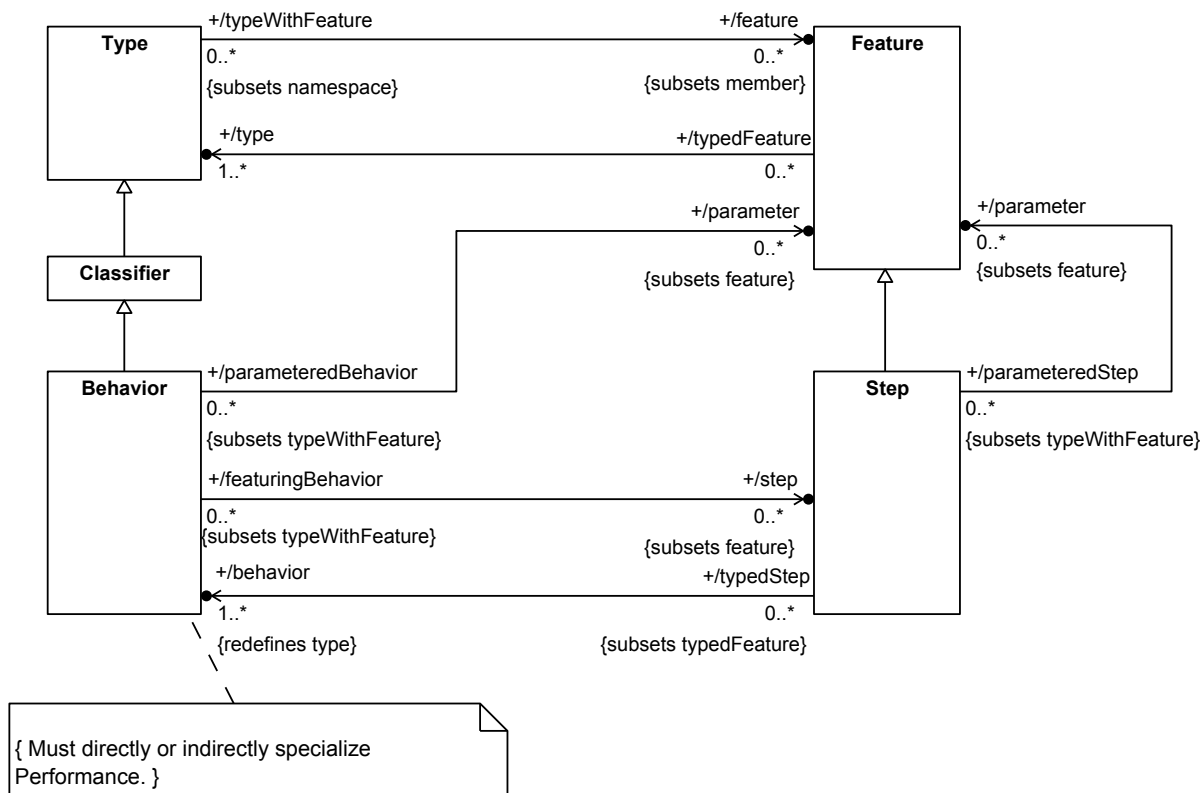


Figure 20. Behaviors

7.2.10 Interactions

7.2.10.1 Interactions Overview

Interactions

Interactions are behaviors that are also associations (see [7.2.9](#) and [7.2.7](#), respectively), whose instances are performances and also links between occurrences. They used to specify how participants affect each other and collaborate. Transfers are a kind of interaction between two participants that specifies when items are provided by one occurrence (via one of its feature) and accepted by another (also via a feature).

Item Flows

Item flows are steps that are also binary connectors (see [7.2.9](#) and [7.2.8](#), respectively) typed as a transfer. An item flow specifies a transfer of items between the Occurrences identified by its first connector end (the transfer source) and its second (the transfer target).

Succession item flows are item flows that are also successions (see [7.2.8](#)), requiring time ordering between their transfer source, the transfer itself, and their transfer target. That is, the transfer happens in the time between the end of the source occurrence and the beginning of the target occurrence.

7.2.10.2 Interactions Concrete Syntax

7.2.10.2.1 Interactions Textual Notation

7.2.10.2.1.1 Interactions

SysML does not provide any concrete syntax for Interactions. The Interaction metaclass shall not be instantiated in a SysML model.

7.2.10.2.1.2 Item Flows

```
ItemFlow (m : Membership) : ItemFlow =
    ( isAbstract ?= 'abstract' )? 'stream'
    ItemFlowDeclaration(this, m) TypeBody(this)

SuccessionItemFlow (m : Membership) : SuccessionItemFlow =
    ( isAbstract ?= 'abstract' )? 'flow'
    ItemFlowDeclaration(this, m) TypeBody(this)

ItemFlowDeclaration (i : ItemFlow, m : Membership) :
    ( FeatureDeclaration(i, m)
      ( 'of' i.ownedFeatureMembership += ItemFeatureMember
        | i.ownedFeatureMembership += EmptyItemFeatureMember )
      'from'
      | i.ownedFeatureMembership += EmptyItemFeatureMember
    )
    i.ownedFeatureMembership += ItemFlowEndMember 'to'
    i.ownedFeatureMembership += ItemFlowEndMember

ItemFeatureMember : FeatureMembership =
    ( memberName = NAME ':' )? ownedMemberFeature = ItemFeature

ItemFeature : Feature =
    ownedTyping += OwnedFeatureTyping
    ( ownedMembership += MultiplicityMember )?
    | ownedMembership += MultiplicityMember
    ( ownedTyping += OwnedFeatureTyping )?

EmptyItemFeatureMember : FeatureMembership =
    ownedMemberFeature = EmptyItemFeature

EmptyItemFeature : Feature =
    {}

ItemFlowEndMember : FeatureMembership =
    ownedMemberFeature = ItemFlowEnd

ItemFlowEnd : Feature =
    ownedFeatureMembership += ItemFlowFeatureMember

ItemFlowFeatureMember : FeatureMembership =
    ownedMemberFeature = ItemFlowFeature

ItemFlowFeature : Feature =
    ownedRedefinition += Redefinition
```

7.2.10.2.2 Interactions Graphical Notation

7.2.10.2.2.1 Interactions

SysML does not provide any concrete syntax for Interactions.

7.2.10.2.2.2 Item Flows

```
kind-keyword (i : ItemFlow) = 'stream'  
kind-keyword (i : SuccessionItemFlow) = 'flow'
```

```
type-dcl-text (i : ItemFlow) =  
    ItemFlowDeclaration (i, i.owningMembership)
```

```
item-feature-label (f : Feature) =  
    element-name-text(f)? feature-typing-text(f)?  
    feature-multiplicity-text(f)?
```

```
element-symbol (i : ItemFlow) =
```

```
    &element-symbol (i.sourceOutputFeature)  $\xrightarrow[\text{item-feature-label(i.itemFeature)?}]{\text{feature-label(i)?}}$  &element-symbol (s.targetInputFeature)
```

Note: Both the feature and item feature labels may be placed on either side of the arrow. If both labels are included, then the kind keyword shall be included in the feature label.

7.2.10.3 Interactions Abstract Syntax

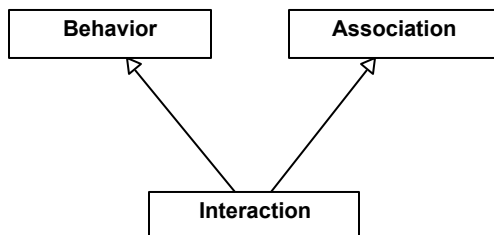


Figure 21. Interactions

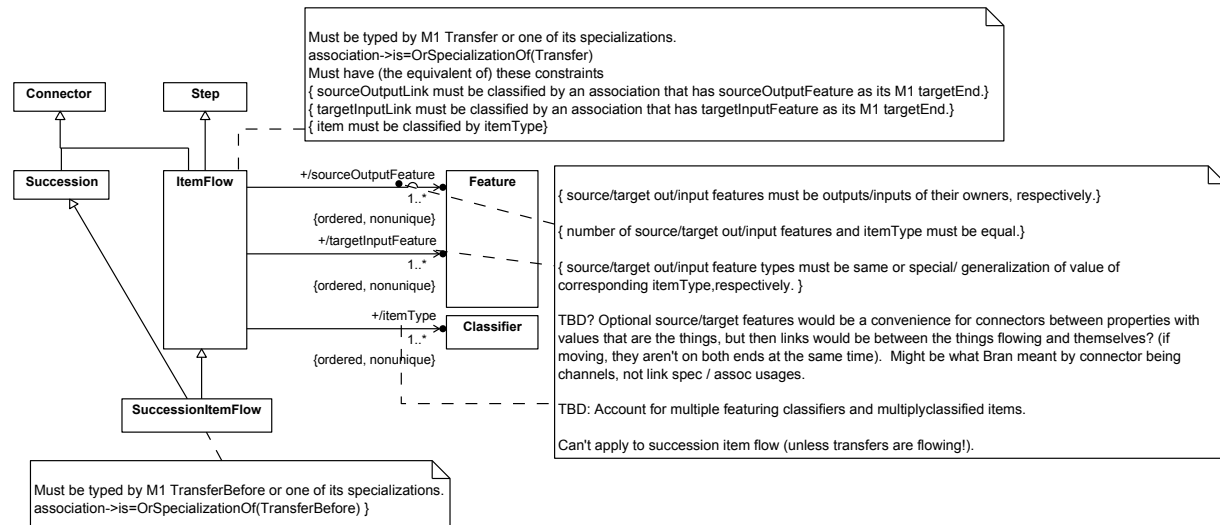


Figure 22. Item Flows

7.2.11 Functions

7.2.11.1 Functions Overview

Functions

Functions are behaviors that designate a single output parameter as their result using a special kind of parameter membership. Functions classify evaluations, which are kind of performances expected to produce values for their result. In general, functions can have output parameter other than their result, and function evaluations can also change involved objects. However, functions with no output parameters other than their result, and which do not change objects during their evaluation, essentially represent mathematical computations (for example, the numerical functions in the Kernel Model Library, see [KerML, 8.16]).

Expressions

Expressions are steps typed only by a single function. They can be steps in any behavior, including functions, in which case one such expression can be designated as specifying the result of the function using a special result-expression membership. The result parameter of a result expression is then bound to the result parameter of the containing function. Expressions can also have their own (nested) parameters, to augment or redefine those of their functions, including the result.

Expressions are commonly organized into tree structures in which the input parameters of each expression are connected by binding connectors to the result of each of its child expressions (its arguments). KerML textual syntax includes traditional operator notation for constructing such Expression trees, which is adopted directly into SysML (see 7.2.12).

Predicates

Predicates are Functions that whose result is a Boolean value. Predicates determine whether the values of their input parameters meet particular conditions at the time of evaluation, returning *true* if they do, and *false* otherwise.

Boolean Expressions and Invariants

Boolean expressions are expressions whose function is a predicate. As such, a Boolean expression must similarly have Boolean result. Invariants are Boolean expressions that must always evaluation to true—a Boolean expression

in general can evaluate to true or false, but an invariant must always evaluate to true in a valid model. (Boolean expressions should not be confused with literal Booleans, which are also expressions, but which are not typed by predicates and always evaluate to *true* or *false*—see 7.2.12).

7.2.11.2 Functions Concrete Syntax

SysML does not provide any concrete syntax for Functions other than CalculationDefinitions (see 7.14), ConstraintDefinitions (see 7.15). SysML adopts the KerML operator notation for Expressions (see 7.2.12) and provides SysML-specific syntax for CalculationUsages (see 7.14), ConstraintUsages (see 7.15), and their various specializations. The Function, Predicate, BooleanExpression and Invariant metaclasses shall not be instantiated in a SysML model.

7.2.11.3 Functions Abstract Syntax

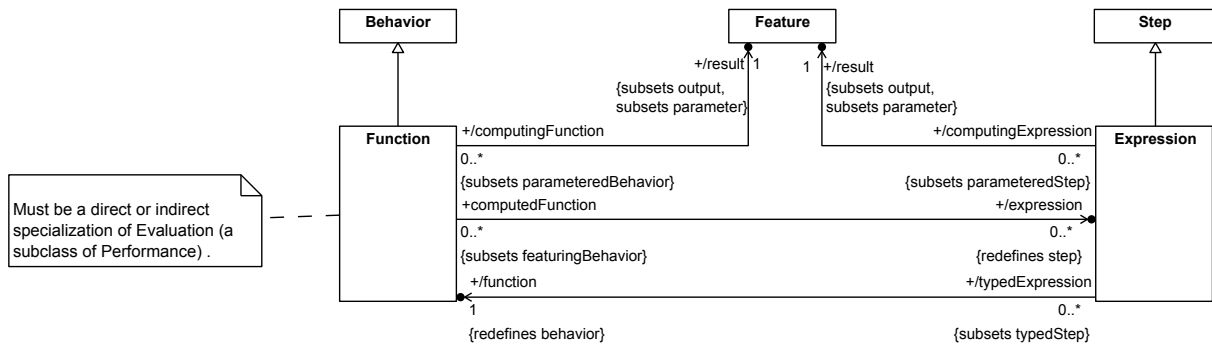


Figure 23. Functions

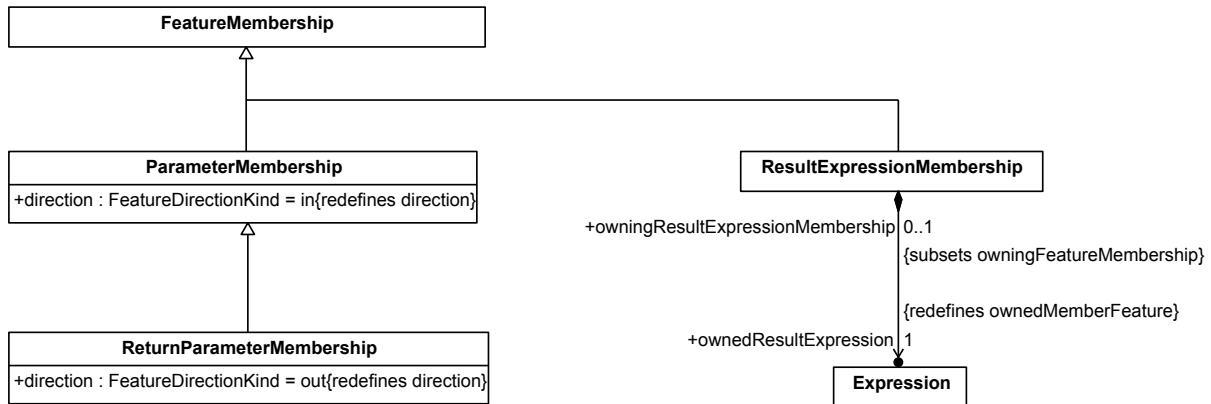


Figure 24. Function Memberships

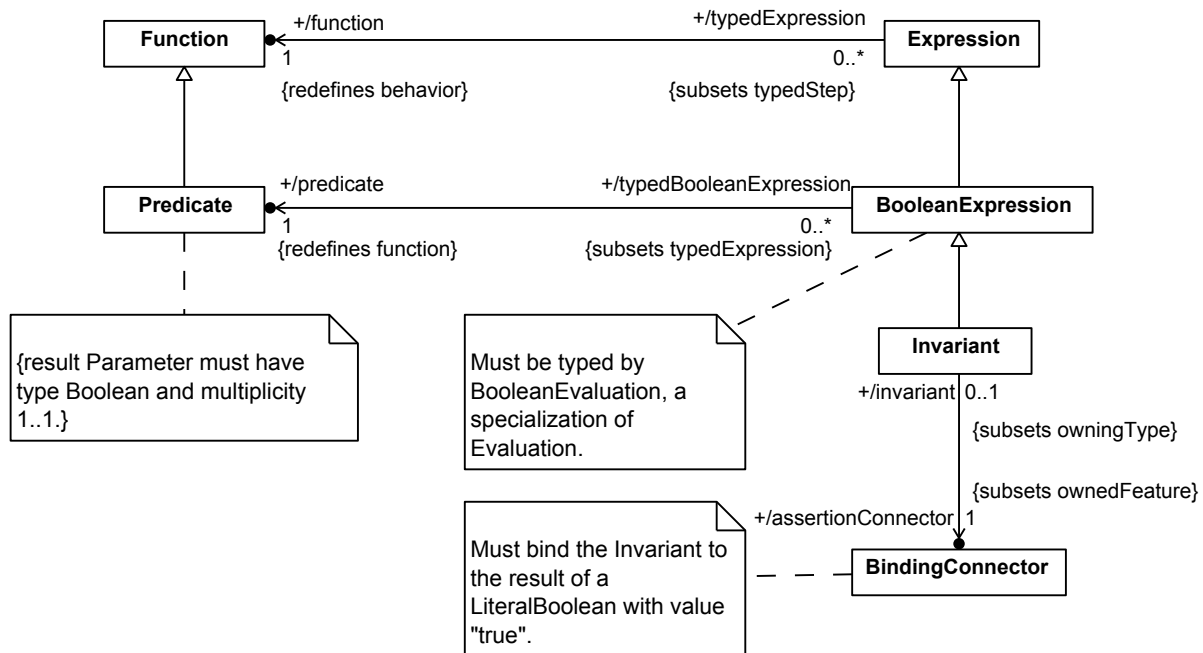


Figure 25. Predicates

7.2.12 Expressions

7.2.12.1 Expressions Overview

Expressions (see Functions) are commonly organized into tree structures to specify compound computations. KerML includes extensive textual syntax for constructing Expression trees, including traditional operator notations for Functions in the Kernel Model Library (see [KerML, Clause 8]), which is adopted in its entirety into SysML. However, these concrete syntax notations map entirely to an abstract syntax involving just a few specialized Expressions:

- The non-leaf nodes of an Expression tree are invocations of function,s with inputs specified as owned argument expressions, one for each of the input parameters of the function.
- The edges of the tree are binding connectors between the input parameters of an invocation expression (redefining those of its function) and the results of its argument expressions.
- The leaf nodes are these kinds of Expressions:
 - Feature reference expressions whose results are values of a reference feature.
 - Literal expressions that result in the literal value of one of the primitive data types from the *ScalarValues* model library (see [KerML, 8.10]).
 - Null expression that result in an empty set of values.

7.2.12.2 Expressions Concrete Syntax

```

OwnedExpressionMember : FeatureMembership =
    ownedFeatureMember = OwnedExpression

OwnedExpression : Expression =
    NullExpression
    | LiteralExpression
    | FeatureReferenceExpression
    | InvocationExpression
    | '(' OwnedExpression ')'

NullExpression : NullExpression =
    'null' | '{' '}'

FeatureReferenceExpression : FeatureReferenceExpression =
    ownedFeatureMembership += FeatureReferenceMember

FeatureReferenceMember : ReturnParameterMembership =
    ownedMemberParameter = FeatureReference

FeatureReference : Feature =
    ownedSubsetting += Subset

InvocationExpression : InvocationExpression =
    ownedTyping += OwnedFeatureTyping '(' ArgumentList(this)? ')'

ArgumentList (e : InvocationExpression) =
    PositionalArgumentList(e) | NamedArgumentList(e)

PositionalArgumentList (e : InvocationExpression) =
    e.ownedFeatureMembership += OwnedExpressionMember
    ( ',' e.ownedFeatureMembership += OwnedExpressionMember ) *

NamedArgumentList (e : InvocationExpression) =
    e.ownedFeatureMembership += NamedExpressionMember
    ( ',' e.ownedFeatureMembership += NamedExpressionMember ) *

NamedExpressionMember : FeatureMembership =
    memberName = NAME '=>' ownedMemberFeature = OwnedExpression

LiteralExpression : LiteralExpression =
    LiteralBoolean
    | LiteralString
    | LiteralInteger
    | LiteralReal
    | LiteralUnbounded

LiteralBoolean : LiteralBoolean =
    value = BooleanValue

BooleanValue : Boolean =
    'true' | 'false'

```



```

LiteralString : LiteralString
    value = STRING_VALUE

LiteralInteger : LiteralInteger =
    value = DECIMAL_VALUE

LiteralReal : LiteralReal =
    value = RealValue

RealValue : Real =
    DECIMAL_VALUE? '.' ( DECIMAL_VALUE | EXPONENTIAL_VALUE )
    | EXPONENTIAL_VALUE

LiteralUnbounded : LiteralUnbounded =
    '*'

```

The above grammar defines a basic functional notation for InvocationExpressions, FeatureReferenceExpressions, NullExpressions, and LiteralExpressions. KerML also provides a rich operator notation for InvocationExpressions (see [KerML, 7.4.7.2]). This notation may also be used in SysML anyplace an InvocationExpression is valid.

There is no graphical notation for Expressions in SysML, other than that provided for CalculationUsages (see [7.14](#)), ConstraintUsages (see [7.15](#)), and their various specializations.

7.2.12.3 Expressions Abstract Syntax

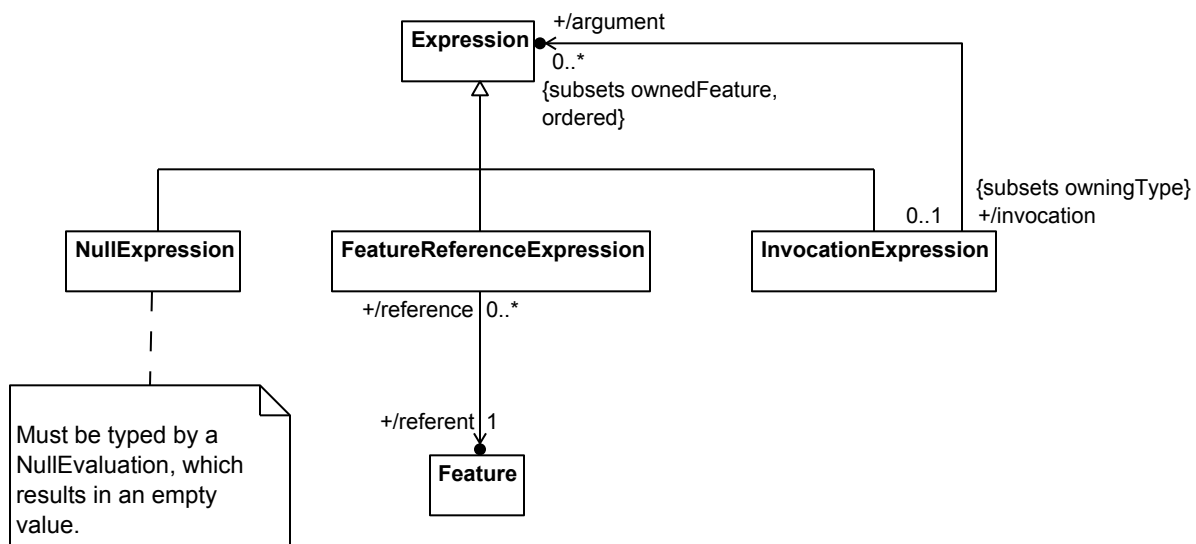


Figure 26. Expressions

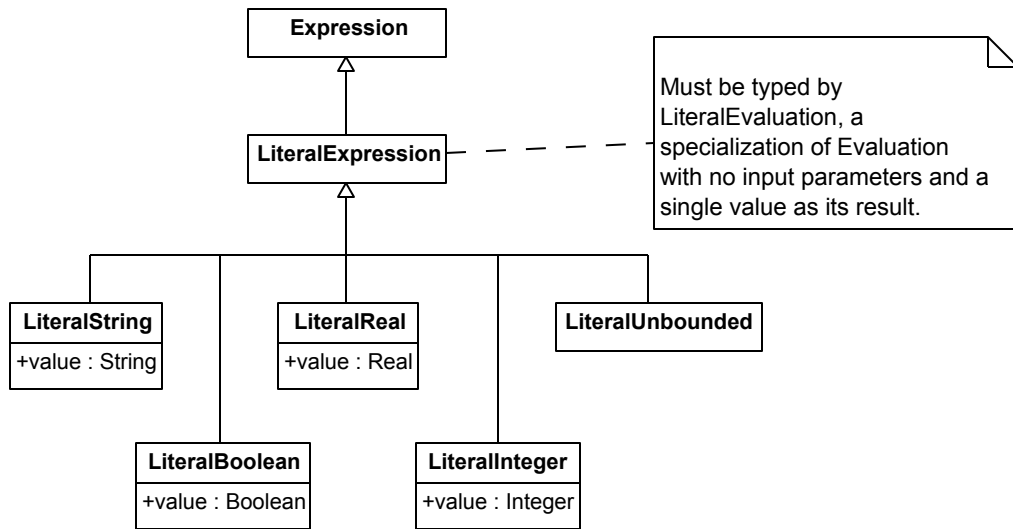


Figure 27. Literal Expressions

7.3 Dependencies

7.3.1 Dependencies Overview

A Dependency is a kind of Relationship between any two elements where the element on the client end depends on the element on the supplier end. This implies that a change to the element on the supplier end may result in a change to the element on the client end.

Dependencies can be useful for representing relationships between elements in an abstract way. For example, a dependency can be used to represent that an upper layer of an architecture stack may depend on a lower layer of the stack. Another example is using a dependency to represent a simplified cause-effect relationship that abstracts away much of the details underlying this relationship. The analysis of cross-model dependencies can support impact assessment and help identify potentially undesired circular dependencies.

7.3.2 Dependencies Concrete Syntax

7.3.2.1 Dependencies Textual Notation

```

Dependency (m : Membership) : Dependency =
    'dependency' DependencyDeclaration(this, m) ';'

DependencyDeclaration (d : Declaration, m : Membership) =
    ( Identification(this, m) 'from' )?
    client += [QualifiedName] ( ',' client += [QualifiedName] )* 'to'
    supplier += [QualifiedName] ( ',' supplier += [QualifiedName] )*

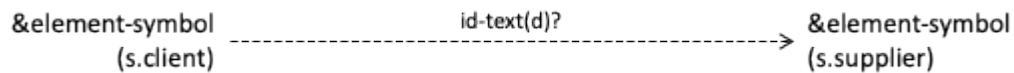
```

7.3.2.2 Dependencies Graphical Notation

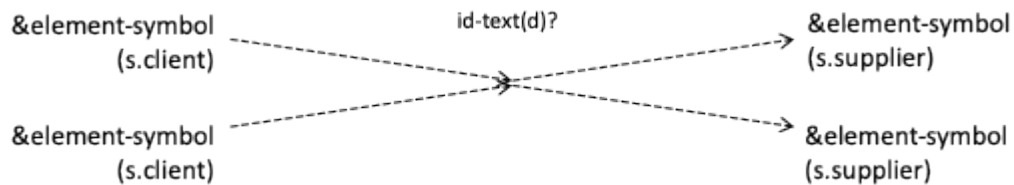
```
element-text (d : Dependency) =  
    visibility-keyword(d)? 'dependency'  
    DependencyDeclaration(d, d.owningMembership)
```

```
element-symbol (d : Dependency) =  
    dependency-binary-symbol(d)  
    | dependency-nary-symbol(d)  
    | dependency-nary-dot-symbol(d)
```

```
dependency-binary-symbol(d) =
```

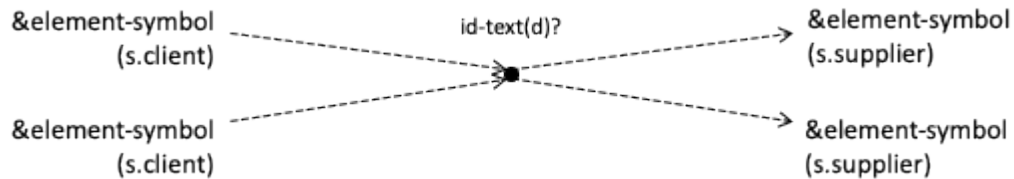


```
dependency-nary-symbol(d) =
```



Note: There may be one or more branches on either side.

```
dependency-nary-dot-symbol(d) =
```



Note: There may be one or more branches on either side.

7.3.3 Dependencies Abstract Syntax

7.3.3.1 Overview

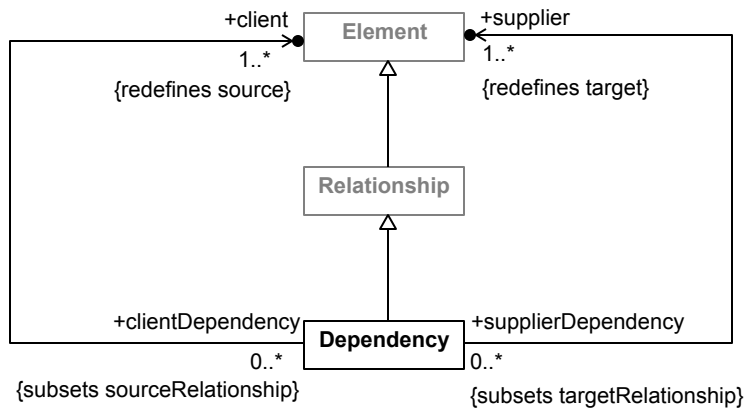


Figure 28. Dependencies

7.3.3.2 Dependency

Description

A Dependency is a Relationship that indicates that one or more `client` Elements require one more `supplier` Elements for their complete specification. In general, this means that a change to one of the `supplier` Elements may necessitate a change to, or re-specification of, the `client` Elements.

Note that a Dependency is entirely a model-level Relationship, without instance-level semantics.

General Classes

Relationship

Attributes

`client` : Element [1..*] {redefines source}

The Element or Elements dependent on the `supplier` elements.

`supplier` : Element [1..*] {redefines target}

The Element or Elements on which the `client` Elements depend in some respect.

Operations

No operations.

Constraints

No constraints.

7.4 Definition and Usage

7.4.1 Definition and Usage Overview

Definitions and Usages

The modeling capabilities of SysML facilitate reuse in different contexts. The `DefinitionElement` and `UsageElement` provide a consistent foundation for many SysML language constructs to provide this capability. This includes definition and usage elements for attributes, items, parts, ports, connections, interfaces, individuals, actions, states, calculations, constraints, requirements, analysis case, verification case, variants, views, and other specializations.

In general, a definition element is a `Classifier` that classifies a certain kind of element (e.g., a classification of attributes, parts, actions, etc.). A definition element may then have owned usage elements nested in it, referred to as its `Features`. A feature has a multiplicity that specifies the number of owned usage elements of this kind. For example, a `Vehicle` definition could include a usage element called `wheels` with multiplicity 4, meaning each `Vehicle` has exactly four wheels, or a less restrictive constraint, such as a multiplicity of 2..8, meaning each `Vehicle` can have 2 to 8 wheels.

A definition element can be specialized using the `Generalization` relationship. The specialized definition element (i.e., subclass) must also conform to the general definition element (i.e., superclass). A specialized definition element inherits the features from the more general definition element and can add other features. For example, if `Vehicle` has a feature called `fuel`, that is defined by `Fuel`, and `Truck` is a specialized kind of `Vehicle`, then `Truck` inherits the feature `fuel` that is defined by `Fuel`. An inherited feature can be over-ridden using redefinition or subsetting as described below. The *Truck* can also add its own features such as `cargoSize`.

A usage element is a usage of a definition element in a certain context. A usage element must always be defined by at least one definition element that corresponds to its usage kind. For example, a part usage is defined by a part definition, and an action usage is defined by an action definition. If no definition is specified explicitly, then the usage is defined implicitly by the most general definition element of the appropriate kind from the Systems Model Library (see [8.1](#)). For example, a part usage is implicitly defined by the most general part definition *Part* from the model library package `Parts`.

A usage element inherits the features from its definition element in the same way that a definition element can specialize a more general definition element. For example, if a part usage `vehicle` is defined by a part definition `Vehicle`, and `Vehicle` has a mass defined by `MassValue`, then `vehicle` inherits the feature `mass` defined by `MassValue`. In some cases, a usage element may have more than one definition element, in which case the usage element combines the features from each of its definition elements.

A usage element can add its own features, and redefine or subset its inherited features. This enables each usage element to be modified for its context. The redefined or subsetted feature must conform to the constraints of the inherited feature.

To redefine an inherited feature, the definition of the redefined feature must be a subclass of the definition of its inherited feature. For the example above, `Vehicle` contains a feature called `fuel` that is defined by `Fuel`. `Truck` inherits `fuel` from `Vehicle`. A part usage called `truck` that is defined by a part definition called `Truck` inherits `fuel` from `Truck`. The part usage `truck` can redefine its `fuel` to be defined by `DieselFuel`, which is a subclass of `Fuel`.

To subset an inherited feature, there can be one or more subsetted features subject to the multiplicity constraints of the inherited feature. For the example above, `Truck` inherits the feature `wheels` with multiplicity 2..8 from `Vehicle`. The part usage `truck` further inherits `wheels` with multiplicity 2..8 from `Truck`. The part usage `truck` can subset `wheels` by defining `frontLeftWheel`, `frontRightWheel`, `rearLeftWheel1`, `rearLeftWheel2`, `rearRightWheel1`, and `rearRightWheel2` as subsets of `wheels`, as long as the number of wheels is between 2 and 8.

A usage element may be a feature of an owning definition element as described above. However, a usage element may also be contained directly in an owning package. In this case, the context for the usage element is the most

general kernel type Anything. That is, a package-level usage is essentially a generic feature that can be applied in any context. This usage enables specializations in specific contexts.

A usage element may also have nested usage elements. In this case, the context for the nested usages is the containing usage. A simple example is illustrated by a parts tree which is defined by a hierarchy of part usages.. A vehicle usage defined by Vehicle could contain part usages for engine, transmission, frontAxle, and rearAxle. Each part usage has its own part definition. A usage with nested usages, such as this vehicle parts tree, can be reused by subsetting the part usage vehicle. Subsetting the part usage vehicle is analogous to specializing the part definition Vehicle. For this example, assume vehicle1 is a part usage that subsets vehicle. This would enable vehicle1 to inherit the features and structure of vehicle. The part usage vehicle1 can be further modified by adding other part usages to it, such as a body and chassis. The part usage vehicle1 could also redefine the parts from vehicle as needed. For example, vehicle1 may redefine engine to be a 4-cylinder engine. The original part vehicle remains unchanged, but vehicle1 is now a unique design configuration. Other part usages such as vehicle2 could be created in a similar way to represent other design configurations.

It should be noted, that if the part definition Vehicle is modified, the modification will propagate down through the specializations described above. However, it is expected that if Vehicle is baselined in a configuration management tool, than a change to Vehicle is a new revision, and it is up to the modelers to determine whether to retain the previous version of Vehicle or move to the next revision.

A usage element may be a reference or composite feature of another usage or definition element. A reference usage element represents a simple reference from one usage to another. A composite usage element indicates that the usage at any point in time is integral to the structure of the containing definition or usage element. As such, when a containing definition or usage element is destroyed, then any of its contained usages are also destroyed. This is commonly known as *composite destruction semantics*.

As noted above, the definition and usage pattern applies broadly to many different kinds of elements, such as attributes, items, ports, actions, states, requirements, and others. This capability provides the ability to reuse models, while at the same time providing the flexibility to make further modifications for each context.

Variability

Variation and *variant* are used to model variability typically associated with a family of design configurations. A variation is commonly referred to as a variation point. A variation identifies an element in the model that can vary from one design configuration to another. One example of a variation is an engine in a vehicle. For each variation, there are design choices called variants. For this example, where the engine is designated as a point of variation, the design choices are a 4-cylinder engine variant or a 6-cylinder engine variant.

A variation can apply to any usage element in the model, such as a part, port, action, attribute, and requirement. The variation can also be applied to a definition element such as a part definition, port definition, action definition, attribute definition, and requirement definition. Variation can also be used to specify an optional choice where the variant is either included or not. An example may be the option to include a sunroof or not in the vehicle.

All possible variants (i.e., choices) must be enumerated for each variation point. For example, the enumerated variants for the engine variation are the 4-cylinder engine and the 6-cylinder engine. Variants can be logically combined to represent additional choices. For example, the enumerated variants can include A, B, and (A and B). Each of these choices are exclusive, meaning only one choice is valid.

A variant is a subset of the variation usage. For example, the 4-cylinder engine and the 6-cylinder engine are subsets of all possible engines. A variant can only apply to a usage element, and not to a definition element.

Variations can be nested within other variations. For example, the 6-cylinder engine may have choices for cylinder bore diameter. The engine is a variation with a 4-cylinder variant and a 6-cylinder variant. The 6-cylinder variant in turn contains a variation point for bore diameter that includes variants for small-bore diameter and large-bore

diameter. There is no restriction on the number of levels of nesting. The bore diameter variation point could also be applied more generally to the cylinder of engine, enabling both the 4-cylinder engine and the 6-cylinder engine to have this variation point.

A model with variability is a model that includes variation and variants. This variability model can be quite complex since the variation can extend to many other aspects of the model including its structure, behavior, requirements, analysis, and verification. Also, the selection of a particular variant often impacts many other design choices that include other parts, connections, actions, states, and attributes. Constraints can be used to constrain the available choices for a given variant. For example, the choice of a 6-cylinder engine may constrain the choice of transmission to be an automatic transmission, whereas the choice of a 4-cylinder engine may allow for both an automatic transmission or a manual transmission.

As noted above, variation and variants are used to construct a model that is sometimes referred to as a superset model which includes the variants to configure all possible design configurations. A particular configuration is selected by selecting a variant for each variation. SysML is intended to provide validation rules that can evaluate whether a particular configuration is a valid configuration based on the choices and constraints provided in the superset model. Variability modeling in SysML can augment other external variability modeling applications, which provide robust capabilities for managing variability across multiple kinds of models such as CAD, CAE, and analysis models, and auto-generating the variant design configurations based on the selections.

The approach to variability modeling in SysML is intended to align with industry standards such as ISO 26580 Feature-based Product Line Engineering.

7.4.2 Definition and Usage Concrete Syntax

7.4.2.1 Definition and Usage Textual Notation

7.4.2.1.1 Definitions


```

DefinitionPrefix (d : Definition) =
    d.isAbstract ?= 'abstract' | d.isVariation ?= 'variation'

Definition (d : Definition, m: Membership) =
    DefinitionDeclaration(d, m) DefinitionBody(d)

DefinitionDeclaration (d : Definition, m : Membership)
    Identification(d, m) SuperclassingPart(d)?

DefinitionBody (t : Type) =
    ';' | '{' DefinitionBodyItem(t)* '}'

DefinitionBodyItem (t : Type) =
    t.ownedMembership += OwnedDocumentation
    | t.ownedMembership += NestedDefinitionMember(t)
    | t.ownedMembership += VariantUsageMember
    | t.ownedFeatureMembership += NestedUsageMember
    | t.ownedFeatureMembership += IndividualUsageMember
    | t.ownedFeatureMembership += IndividualSuccessionMember(t)
    | t.ownedImport += PackageImport

NestedDefinitionMember (t : Type) : Membership =
    NonFeatureTypeMember(t)

VariantUsageMember : VariantMembership =
    DefinitionMemberPrefix(this) 'variant'
    ownedVariantUsage = VariantUsageElement(this)

NestedUsageMember : FeatureMembership =
    StructureUsageMember | BehaviorUsageMember | FlowUsageMember

StructureUsageMember : FeatureMembership =
    DefinitionMemberPrefix(this)
    ownedMemberFeature = StructureUsageElement(this)

BehaviorUsageMember : FeatureMembership =
    DefinitionMemberPrefix(this)
    ownedMemberFeature = BehaviorUsageElement(this)

IndividualUsageMember : FeatureMembership =
    DefinitionMemberPrefix(this)
    ownedFeatureMember = IndividualUsageElement(this)

IndividualSuccessionMember (t : Type) : FeatureMembership =
    s = SourceSuccessionMember(t)
    IndividualUsageMember
    TargetEndFor(s.ownedMemberFeature, ownedMemberFeature)

FlowUsageMember : FeatureMembership =
    DefinitionMemberPrefix(this)
    direction = FeatureDirection

```

```
ownedFeatureMember = FlowUsageElement(this)
DefinitionMemberPrefix (m : Membership) =
  TypeMemberPrefix(m)
```

7.4.2.1.2 Usages

```

UsagePrefix (u : Usage) =
    u.isAbstract ?= 'abstract' | u.isVariation ?= 'variation'

Usage (u : Usage, m : Membership) =
    UsageDeclaration(this, m) UsageCompletion(this)

UsageDeclaration (u : Usage, m : Membership) =
    FeatureDeclaration(u, m)

UsageCompletion (u : Usage) =
    ValueorFlowPart(this)? UsageBody(this)

UsageBody (u : Usage) =
    DefinitionBody(u)

ValueOrFlowPart (u : Usage) =
    ValuePart(u) | FlowPart(u)

FlowPart (f : Feature) =
    f.ownedMembership += SourceItemFlowMember(f)

SourceItemFlowMember (f : Feature) : FeatureMembership =
    ownedMemberFeature = SourceItemFlow(f)

SourceItemFlow (f : Feature) : ItemFlow =
    ItemFlowTo(f) | SuccessionItemFlowTo(f)

ItemFlowTo (f : Feature) : ItemFlow =
    'stream' ownedFeatureMembership += EmptyItemFeatureMember
    'from' ownedFeatureMembership += ItemFlowEndMember
    ownedFeatureMembership += ItemFlowEndMemberFor(f)

SuccessionItemFlowTo (f : Feature) : SuccessionItemFlow =
    'flow' ownedFeatureMembership += EmptyItemFeatureMember
    'from' ownedFeatureMembership += ItemFlowEndMember
    ownedFeatureMembership += ItemFlowEndMemberFor(f)

ItemFlowEndMemberFor (f : Feature) : FeatureMembership =
    ownedMemberFeature = ItemFlowEndFor (f)

ItemFlowEndFor (f : Feature) : Feature =
    ownedFeatureMembership += ItemFlowFeatureMemberFor(f)

ItemFlowFeatureMemberFor (f : Feature) : FeatureMembership =
    ownedMemberFeature = ItemFlowFeatureFor(f)

ItemFlowFeatureFor (f : Feature) : Feature =
    ownedRedefinition += OwnedRedefinitionFor(f)

OwnedRedefinitionFor (f : Feature) : Redefinition =
    { redefinedFeature = f }

```

7.4.2.1.3 Reference Usages

```
ReferenceUsage (m : Membership) : ReferenceUsage =  
    UsagePrefix(this)? 'ref' Usage(this, m)  
  
ReferenceEndUsage (m : Membership) : ReferenceUsage =  
    UsagePrefix(this)? 'ref'? Usage(this, m)  
  
ReferenceVariantUsage (m : Membership) : ReferenceUsage =  
    ReferenceUsage  
    | ownedSubsetting += OwnedSubsetting  
    FeatureSpecialization* UsageBody
```

7.4.2.1.4 Body Elements

```

StructureUsageElement (m : Membership) : Usage =
    ReferenceUsage (m)
  | AttributeUsage (m)
  | ItemRefUsage (m)
  | PartRefUsage (m)
  | ViewRefUsage (m)
  | RenderingRefUsage (m)
  | PortUsage (m)
  | ConnectionUsage (m)
  | Connector (m)
  | InterfaceUsage (m)
  | BindingConnector (m)
  | Succession (m)
  | ItemFlow (m)
  | SuccessionItemFlow (m)

IndividualUsageElement (m : Membership) : IndividualUsage =
    IndividualRefUsage (m)
  | TimeSliceRefUsage (m)
  | SnapshotRefUsage (m)

BehaviorUsageElement (m : Membership) : Usage =
    ActionRefUsage (m)
  | CalculationRefUsage (m)
  | StateRefUsage (m)
  | ConstraintRefUsage (m)
  | RequirementRefUsage (m)
  | CaseRefUsage (m)
  | AnalysisCaseRefUsage (m)
  | VerificationCaseRefUsage (m)
  | ViewpointRefUsage (m)
  | PerformActionUsage (m)
  | ExhibitStateUsage (m)
  | AssertConstraintUsage (m)
  | SatisfyRequirementUsage (m)

VariantUsageElement (m) : Usage =
    ReferenceVariantUsage (m)
  | AttributeVariantUsage (m)
  | ItemRefUsage (m)
  | PartRefUsage (m)
  | PortUsage (m)
  | ConnectionUsage (m)
  | Connector (m)
  | InterfaceUsage (m)
  | IndividualUsageElement (m)
  | BehaviorUsageElement (m)

FlowUsageElement (m : Membership) : Usage :
    ReferenceUsage (m)
  | AttributeUsage (m)

```

```

| ItemFlowUsage (m)
| PartFlowUsage (m)
| ViewFlowUsage (m)
| RenderingFlowUsage (m)
| ActionFlowUsage (m)
| CalculationFlowUsage (m)
| StateFlowUsage (m)
| ConstraintFlowUsage (m)
| RequirementFlowUsage (m)
| CaseFlowUsage (m)
| AnalysisCaseFlowUsage (m)
| VerificationCaseFlowUsage (m)
| ViewpointFlowUsage (m)

```

7.4.2.2 Definition and Usage Graphical Notation

7.4.2.2.1 Definitions

```

variation-keyword (d : Definition) =
    'variation' (d.isVariation)

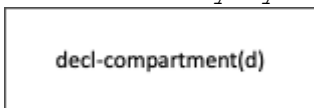
end-keyword (d : Definition) = none

type-decl-text (d : Definition) =
    DefinitionDeclaration(d, d.owningMembership)

element-symbol (d : definition) =
    ( definition-no-body-symbol(d)
    | definition-with-body-symbol(d)
    ) boundary-feature-graphic(d.usage, d)*

definition-no-body-symbol (d : Definition) =

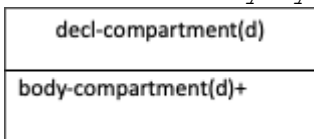
```



```

definition-with-body-symbol (d : Definition) =

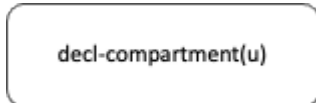
```



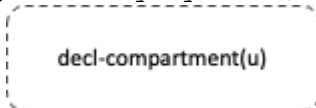
7.4.2.2.2 Usages

```
variation-keyword (u : Usage) =  
    'variation' (u.isVariation)  
  
end-keyword (u : Usage) =  
    'end' (u.isEnd)  
  
type-decl-text (u : Usage) =  
    UsageDeclaration(u, u.owningMembership)  
  
element-symbol (u : Usage) =  
    ( usage-no-body-symbol(u, u.isComposite)  
    | usage-with-body-symbol(u, u.isComposite)  
    ) boundary-feature-graphic(u.usage, u)*
```

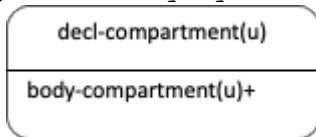
```
usage-no-body-symbol (u : Usage, true) =
```



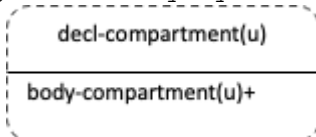
```
usage-no-body-symbol (u : Usage, false) =
```



```
usage-with-body-symbol (u : Usage, true) =
```



```
usage-with-body-symbol (u : Usage, false) =
```



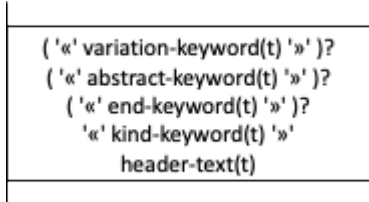
```
kind-keyword (u : ReferenceUsage) = 'ref'
```

```
ref-keyword (u : ReferenceUsage) = none
```

Note: A ReferenceUsage is never composite and a ref keyword would be redundant with its kind keyword.

7.4.2.2.3 Compartments

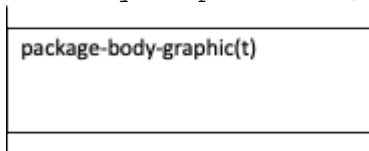
```
header-text (t : Type) =  
    visibility-keyword(t)? direction-keyword(t)? type-dcl-text(t)  
  
direction-keyword (d : Definition) = none  
direction-keyword (u : Usage) = direction-keyword(u.owningFeatureMembership)  
  
decl-compartment (t : Type) =
```



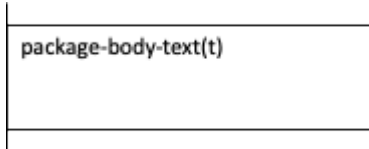
(Note: As an alternative to using the 'abstract' keyword, the header text can be rendered in italics.)

```
body-compartment (t : Type) =  
    graphic-body-compartment (t) | text-body-compartment (t) | ...
```

```
graphic-body-compartment (t : Type) =
```



```
text-body-compartment (t : Type) =
```



```
compartment-element-text (t : Type) =  
    visibility-keyword(t) variation-keyword(t)? abstract-keyword(t)?  
    end-keyword(t)? ref-keyword(t)? type-decl-text(t)  
    element-graphic(t.ownedAnnotation) *
```

```
keyword-element-text (t : Type, k : String) =  
    visibility-keyword(t) variation-keyword(t)? abstract-keyword(t)?  
    KEYWORD(k) ref-keyword(t)? type-decl-text(t)  
    element-graphic(t.ownedAnnotation) *
```

Notes

- Additional kinds of body compartments are given in subsequent subclauses.
- *Compartment element text* does not include the kind keyword. It is used in compartments in which the element kind is already determined by the compartment kind.

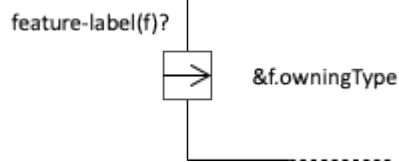
- *Keyword element text* is used in compartments for element declarations that require an extra keyword to be inserted.

7.4.2.2.4 Boundary Features

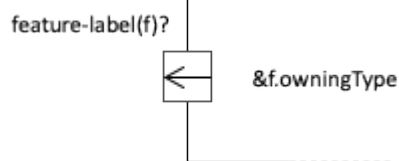
```
boundary-feature-graphic (f : Feature, t : Type) =
  boundary-feature-symbol(f, f.directionFor(t))
  boundary-feature-graphic(f.usage, f)
  element-graphic(f.ownedAnnotation) *
```

```
boundary-feature-symbol (f : Feature, null) = none
```

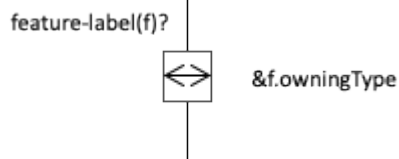
```
boundary-feature-symbol (f : Feature, FeatureDirectionKind::in) =
```



```
boundary-feature-symbol (f : Feature, FeatureDirectionKind::out) =
```



```
boundary-feature-symbol (f : Feature, FeatureDirectionKind::inout) =
```



Note: Boundary Feature symbols can appear anywhere on the boundary of the owningType symbol. The in and out arrows are relative to the inside and outside of the owningType symbol.

Any flowFeature (i.e., a Feature with a non-null direction) of a Definition or Usage can be shown using a *boundary feature symbol*. By default, Features without direction cannot be shown using such symbols, though Ports can be (see [7.8.2.2](#)).

Note that internal features may not be shown on a boundary feature symbols, but it may have nested boundary features. The outer boundary feature symbol can be resized as necessary to accommodate this.

7.4.2.2.5 Variant Memberships

```

package-membership-graphic (m : VariantMembership) =
    &element-symbol (m.membershipOwningPackage) ⊕ visibility-text(m.visibility)? '«variant»' &element-symbol (m.ownedVariantUsage)

```

7.4.3 Definition and Usage Abstract Syntax

7.4.3.1 Overview

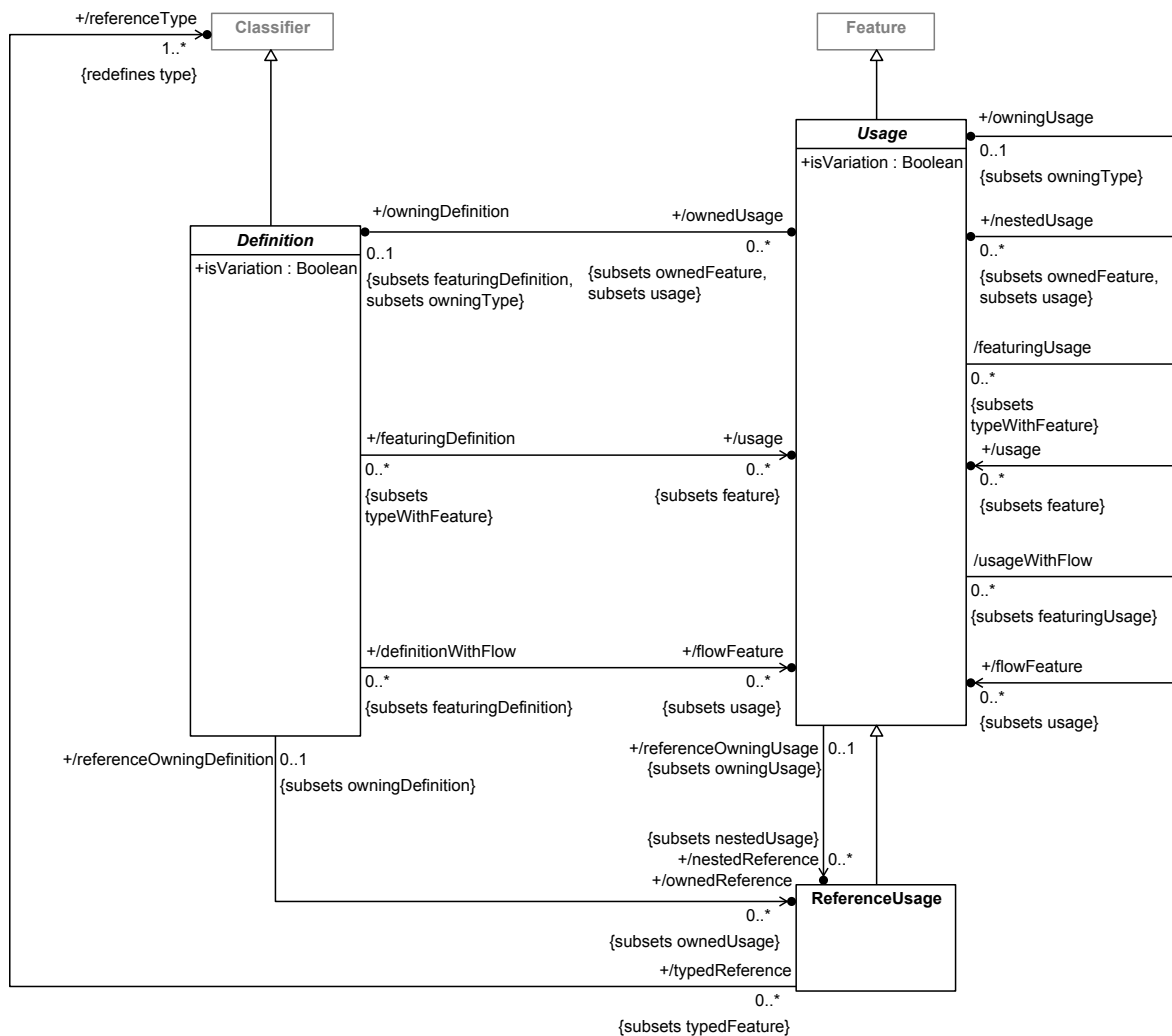


Figure 29. Definition and Usage

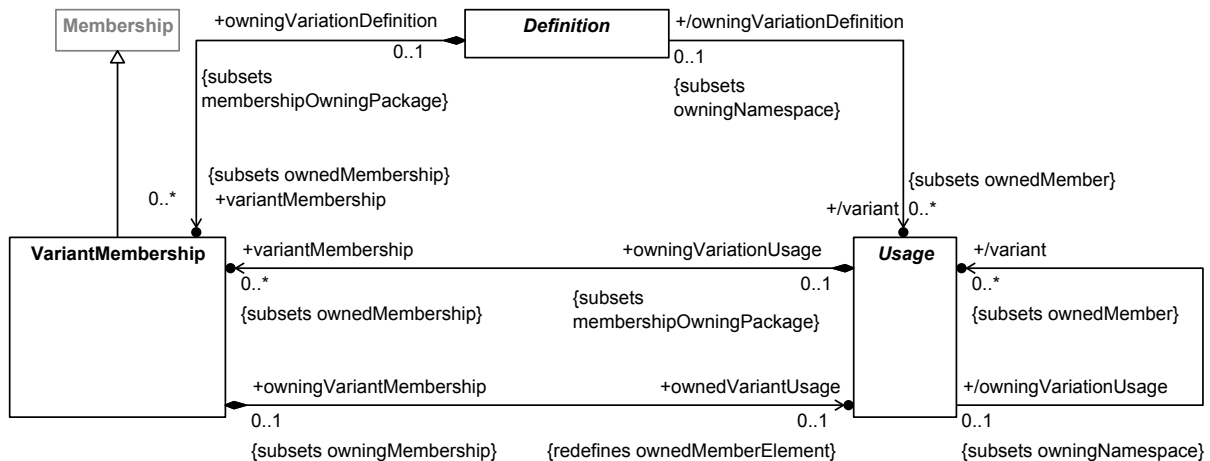


Figure 30. Variant Membership

7.4.3.2 Definition

Description

A Definition is a Classifier of Usages. The actual kinds of Definitions that may appear in a model are given by the concrete subclasses of Definition.

Normally, a Definition has owned Usages that model *features* of the thing being defined. A Definition may also have other Definitions nested in it, but this has no semantic significance, other than the nested namespace scoping resulting from the Definition being considered as a Package for any nested Definitions.

However, if a Definition has `isVariation = true`, then it represents a *variation point* Definition. In this case, all of its members must be *variant* Usages, related to the Definition by VariantMembership Relationships. Rather than being *features* of the Definition, *variant* Usages model different concrete alternatives that can be chosen to fill in for an abstract Usage of the variation point Definition.

General Classes

Classifier

Attributes

/flowFeature : Usage [0..*] {subsets usage}

The usages of this Definition that have a non-null `direction`.

isVariation : Boolean

Whether this Definition is for a variation point or not. If true, then all the `memberships` of the Definition must be VariantMemberships.

/ownedAction : ActionUsage [0..*] {subsets ownedUsage}

The ActionUsages that are `ownedUsages` of this Definition.

/ownedAnalysisCase : AnalysisCaseUsage [0..*] {subsets ownedCase}

The AnalysisCaseUsages that are ownedUsages of this Definition.

/ownedAttribute : AttributeUsage [0..*] {subsets ownedUsage}

The AttributeUsages that are ownedUsages of this Definition.

/ownedCalculation : CalculationUsage [0..*] {subsets ownedAction}

The CalculationUsages that are ownedUsages of this Definition.

/ownedCase : CaseUsage [0..*] {subsets ownedCalculation}

The CaseUsages that are ownedUsages of this Definition.

/ownedConnection : ConnectionUsage [0..*] {subsets ownedPart}

The ConnectionUsages that are ownedUsages of this Definition.

/ownedConstraint : ConstraintUsage [0..*] {subsets ownedUsage}

The ConstraintUsages that are ownedUsages of this Definition.

/ownedIndividual : IndividualUsage [0..*] {subsets ownedItem}

The IndividualUsages that are ownedUsages of this Definition.

/ownedInterface : InterfaceUsage [0..*] {subsets ownedConnection}

The InterfaceUsages that are ownedUsages of this Definition.

/ownedItem : ItemUsage [0..*] {subsets ownedUsage}

The ItemUsages that are ownedUsages of this Definition.

/ownedPart : PartUsage [0..*] {subsets ownedItem}

The PartUsages that are ownedUsages of this Definition.

/ownedPort : PortUsage [0..*] {subsets ownedUsage}

The PortUsages that are ownedUsages of this Definition.

/ownedReference : ReferenceUsage [0..*] {subsets ownedUsage}

The ReferenceUsages that are ownedUsages of this Definition.

/ownedRendering : RenderingUsage [0..*] {subsets ownedPart}

The usages of this Definition that are RenderingUsages.

/ownedRequirement : RequirementUsage [0..*] {subsets ownedConstraint}

The RequirementUsages that are ownedUsages of this Definition.

/ownedState : StateUsage [0..*] {subsets ownedUsage}

The StateUsages that are ownedUsages of this Definition.

/ownedTransition : TransitionUsage [0..*] {subsets ownedUsage}

The TransitionUsages that are ownedUsages of this Definition.

/ownedUsage : Usage [0..*] {subsets ownedFeature, usage}

The Usages that are ownedFeatures of this Definition.

/ownedVerificationCase : VerificationCaseUsage [0..*] {subsets ownedCase}

The ownedUsages of this Definition that are VerificationCaseUsages.

/ownedView : ViewUsage [0..*] {subsets ownedPart}

The ownedUsages of this Definition that are ViewUsages.

/ownedViewpoint : ViewpointUsage [0..*] {subsets ownedRequirement}

The ownedUsages of this Definition that are ViewpointUsages.

/usage : Usage [0..*] {subsets feature}

The Usages that are features of this Definition (not necessarily owned).

/variant : Usage [0..*] {subsets ownedMember}

The Usages which represent the variants of this Definition as a variation point Definition, if `isVariation = true`. If `isVariation = false`, there must be no variants.

variantMembership : VariantMembership [0..*] {subsets ownedMembership}

The ownedMemberships of this Definition that are VariantMemberships. If `isVariation = true`, then this must be all memberships of the Definition. If `isVariation = false`, then `variantMembership` must be empty.

Operations

No operations.

Constraints

No constraints.

7.4.3.3 ReferenceUsage

Description

A ReferenceUsage is a Usage that specifies a non-compositional (`isComposite = false`) reference to something. The type of a ReferenceUsage can be any kind of Classifier, with the default being the top-level Classifier Anything from the Kernel library. This allows the specification of a generic reference without

distinguishing if the thing referenced is an attribute value, item, action, etc. All features of a `ReferenceUsage` must also have `isComposite = false`.

General Classes

Usage

Attributes

`/referenceType : Classifier [1..*] {redefines type}`

The types of this `ReferenceUsage`, which must all be `Classifiers`.

Operations

No operations.

Constraints

No constraints.

7.4.3.4 Usage

Description

A `Usage` is a usage of a `Definition`. A `Usage` may only be an `ownedFeature` of a `Definition` or another `Usage`.

A `Usage` may have `nestedUsages` that model features that apply in the context of the `owningUsage`. A `Usage` may also have `Definitions` nested in it, but this has no semantic significance, other than the nested namespace scoping resulting from the `Usage` being considered as a `Package` for any nested `Definitions`.

However, if a `Usage` has `isVariation = true`, then it represents a *variation point* `Usage`. In this case, all of its `members` must be `variant Usages`, related to the `Usage` by `VariantMembership Relationships`. Rather than being features of the `Usage`, `variant Usages` model different concrete alternatives that can be chosen to fill in for the variation point `Usage`.

General Classes

Feature

Attributes

`/flowFeature : Usage [0..*] {subsets usage}`

The usages of this `Usage` that have a non-null `direction`.

`isVariation : Boolean`

Whether this `Usage` is for a variation point or not. If true, then all the `memberships` of the `Usage` must be `VariantMemberships`.

`/nestedAction : ActionUsage [0..*] {subsets nestedUsage}`

The `ActionUsages` that are `ownedUsages` of this `Usage`.

/nestedAnalysisCase : AnalysisCaseUsage [0..*] {subsets nestedCase}

The AnalysisCaseUsages that are ownedUsages of this Usage.

/nestedAttribute : AttributeUsage [0..*] {subsets nestedUsage}

The AttributeUsages that are ownedUsages of this Usage.

/nestedCalculation : CalculationUsage [0..*] {subsets nestedAction}

The CalculationUsage that are ownedUsages of this Usage.

/nestedCase : CaseUsage [0..*] {subsets nestedCalculation}

The CaseUsages that are ownedUsages of this Usage.

/nestedConnection : ConnectionUsage [0..*] {subsets nestedPart}

The ConnectionUsages that are nestedUsages of this Usage.

/nestedConstraint : ConstraintUsage [0..*] {subsets nestedUsage}

The ConstraintUsages that are ownedUsages of this Usage.

/nestedIndividual : IndividualUsage [0..*] {subsets nestedItem}

nestedUsages of this Usage.

/nestedInterface : InterfaceUsage [0..*] {subsets nestedConnection}

The InterfaceUsages that are ownedUsages of this Usage.

/nestedItem : ItemUsage [0..*] {subsets nestedUsage}

The ItemUsages that are nestedUsages of this Usage.

/nestedPart : PartUsage [0..*] {subsets nestedItem}

The PartUsages that are nestedUsages of this Usage.

/nestedPort : PortUsage [0..*] {subsets nestedUsage}

The PortUsages that are ownedUsages of this Usage.

/nestedReference : ReferenceUsage [0..*] {subsets nestedUsage}

/nestedRendering : RenderingUsage [0..*] {subsets nestedPart}

The nestedUsages

of this Usage that are RenderingUsages.

/nestedRequirement : RequirementUsage [0..*] {subsets nestedConstraint}

The RequirementUsages that are ownedUsages of this Usage.

/nestedState : StateUsage [0..*] {subsets nestedAction}

The StateUsages that are ownedUsages of this Usage.

/nestedTransition : TransitionUsage [0..*] {subsets nestedUsage}

The TransitionUsages that are ownedUsages of this Usage.

/nestedUsage : Usage [0..*] {subsets ownedFeature, usage}

The Usages that are ownedFeatures of this Usage.

/nestedVerificationCase : VerificationCaseUsage [0..*] {subsets nestedCase}

The nestedUsages of this Usage that are VerificationCaseUsages

/nestedView : ViewUsage [0..*] {subsets nestedPart}

The nestedUsages of this Usage that are ViewUsages.

/nestedViewpoint : ViewpointUsage [0..*] {subsets nestedRequirement}

The nestedUsages

of this Usage that are ViewpointUsages.

/owningDefinition : Definition [0..1] {subsets owningType, featuringDefinition}

The Definition that owns this Usage (if any).

/owningUsage : Usage [0..1] {subsets owningType}

The Usage in which this Usage is nested (if any).

/usage : Usage [0..*] {subsets feature}

The Usages that are features of this Usage (not necessarily owned).

/variant : Usage [0..*] {subsets ownedMember}

The Usages which represent the variants of this Usage as a variation point Usage, if isVariation = true. If isVariation = false, there must be no variants.

variantMembership : VariantMembership [0..*] {subsets ownedMembership}

The ownedMemberships of this Usage that are VariantMemberships. If isVariation = true, then this must be all memberships of the Usages. If isVariation = false, then variantMembership must be empty.

Operations

No operations.

Constraints

No constraints.

7.4.3.5 VariantMembership

Description

A VariantMembership is a Membership between a variation point Definition or Usage and a Usage that represents a variant in the context of that variation. The membershipOwningPackage for the VariantMembership must be either a Definition or a Usage with isVariation = true.

General Classes

Membership

Attributes

ownedVariantUsage : Usage [0..1] {redefines ownedMemberElement}

The Usage that represents a variant in the context of the owningVariationDefinition or owningVariationUsage.

Operations

No operations.

Constraints

No constraints.

7.4.4 Definition and Usage Semantics

7.5 Attributes

7.5.1 Attributes Overview

An AttributeDefinition is a data type that defines a set of data values, such as numbers, quantitative values with units, qualitative values such as text strings, or a composite structure of such values. An AttributeUsage is a kind of Usage element. An attribute usage is a usage of an attribute definition.

The data values of an attribute usage are constrained to be in the range specified by its definition. The range of data values for an attribute definition can be further restricted using constraints (see [7.15](#)). An enumeration is a specialized kind of attribute definition that further restricts the values of the data type to a discrete set of data values.

Submission Note. Support for enumerations will be provided in the revised submission.

Attribute usages can be defined by KerML data types as well as SysML attribute definitions. This allows them to be typed by primitive data types from the Kernel Model Library, such as String, Boolean, and numeric types including Integer, Rational, Real and Complex. The Kernel Model Library also includes basic structured data types for collections and non-scalar values, such as vectors and tensors.

Attribute usages representing quantities with units are defined using the SysML Quantities and Units Model Library or extensions of the elements in this library (see [8.2](#)). The QuantityValue attribute definition in the library provides the base for all such quantities, along with other models that specify the full set of international standard quantity kinds and units. Fundamental to this approach is the principle that only the kind of unit (e.g., MassUnit, LengthUnit, TimeUnit, etc.) is associated with an attribute definition, while a specific unit (e.g., kilogram, meter, second, etc.) is only given with an actual quantity value. This means that an attribute usage for a quantity value is independent of

the specific units used, allowing for automatic conversion and interoperability between different units of the same kind (e.g., kilograms and pounds mass, meters and feet, etc.).

Attributes definition and usages can specify state variables that can vary over time (see [7.11](#)).

7.5.2 Attributes Concrete Syntax

7.5.2.1 Attributes Textual Notation

```
AttributeDefinition (m : Membership) : AttributeDefinition =
    DefinitionPrefix(this)? ( 'attribute' 'def' | 'value' 'type' )
    DefinitionDeclaration(this, m) DefinitionBody(this)

AttributeUsage (m : Membership) : AttributeUsage =
    UsagePrefix(this)? ( 'attribute' | 'value' )?
    Usage(this, m)

AttributeVariantUsage (m : Membership) : AttributeUsage =
    UsagePrefix(this)? ( 'attribute' | 'value' )
    Usage(this, m)
```

7.5.2.2 Attributes Graphical Notation

```
kind-keyword (a : AttributeDefinition) = 'attribute' 'def' | 'value' 'type'
kind-keyword (a : AttributeUsage) = 'attribute' | 'value'
body-compartment (t : Type) = ... | attributes-compartment(t)
attributes-compartment (t : Type) =
    

|                                                                  |
|------------------------------------------------------------------|
| <i>'attributes'   'values'</i><br>attributes-compartment-text(t) |
|------------------------------------------------------------------|



attributes-compartment-text (d : Definition) =
    compartment-element-text(d.ownedAttribute) *

attributes-compartment-text (u : Usage) =
    compartment-element-text(u.nestedAttribute) *
```

7.5.3 Attributes Abstract Syntax

7.5.3.1 Overview

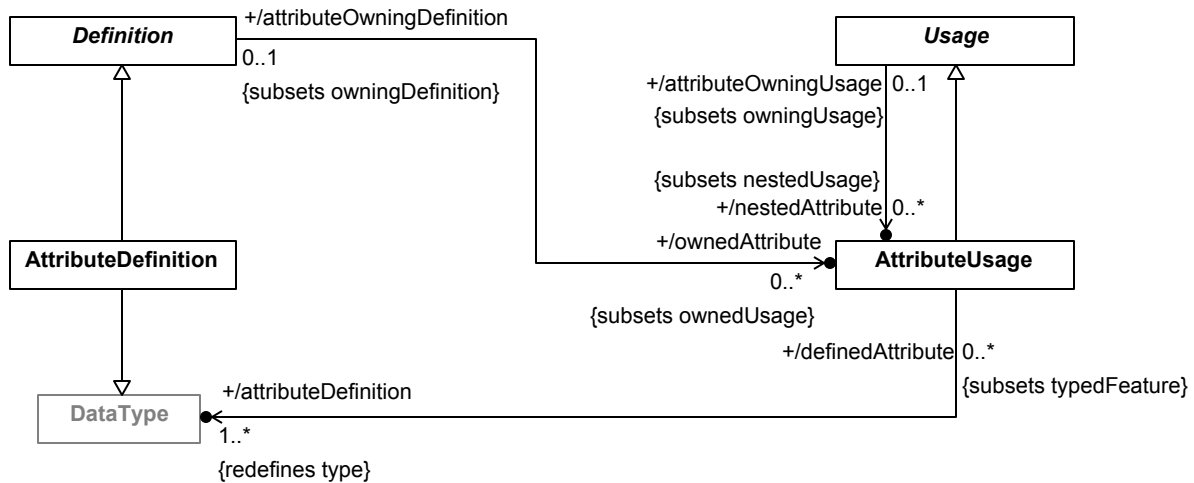


Figure 31. Attribute Definition and Usage

7.5.3.2 AttributeUsage

Description

An **AttributeUsage** is a **Usage** whose type is a **DataType**. Nominally, if the type is an **AttributeDefinition**, an **AttributeUsage** is a usage of a **AttributeDefinition** to represent the value of some system quality or characteristic. However, other kinds of kernel **DataTypes** are also allowed, to permit use of **DataTypes** from the Kernel Library. An **AttributeUsage** itself as well as all its nested **features** must have `isComposite = false`.

A **AttributeUsage** must subset, directly or indirectly, the base **AttributeUsage** `attributeValues` from the Systems model library.

General Classes

Usage

Attributes

`/attributeDefinition : DataType [1..*] {redefines type}`

The **DataTypes** that are the types of this **AttributeUsage**. Nominally, these are **AttributeDefinitions**, but other kinds of kernel **DataTypes** are also allowed, to permit use of **DataTypes** from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.5.3.3 AttributeDefinition

Description

An `AttributeDefinition` is a `Definition` and a `DataType` of information about a quality or characteristic of a system or part of a system that has no independent identity other than its value. All features of an `AttributeDefinition` must have `isComposite = false`.

General Classes

`Definition`
`DataType`

Attributes

No attributes.

Constraints

No constraints.

7.5.4 Attributes Semantics

7.6 Items

7.6.1 Items Overview

An `ItemDefinition` is a `DefinitionElement` that defines a class of things that may be acted on, but which do not necessarily perform actions. An `ItemUsage` is a kind of `Usage` element.

An item usage is a usage of one more item definitions. Item usages are used to represent inputs and outputs to actions such as water, fuel or electrical signals, Item usages such as fuel, may flow through a system, and be stored by a system. An item definition and usage may have attributes, states (see [7.13](#)), and be decomposed into nested item usages.

An individual item is an object that has an extent in time and may have spatial extent. The extent of an individual item in time is known as its lifetime, which covers the period in time from the item's creation to its destruction. An individual item maintains its identity over its lifetime, while the values of its features may change over time. (see [7.11](#) on the modeling of individuals, time slices and snapshots).

7.6.2 Items Concrete Syntax

7.6.2.1 Items Textual Notation

```
ItemDefinition (m : Membership) : PartDefinition =  
    DefinitionPrefix? 'item' 'def' Definition(this, m)  
  
ItemUsage (m : Membership) : ItemUsage =  
    UsagePrefix? 'item' Usage(this, m)  
  
ItemFlowUsage (m : Membership) : ItemUsage =  
    UsagePrefix? 'ref'? 'item' Usage(this, m)  
  
ItemRefUsage (m : Membership) : ItemUsage =  
    UsagePrefix? ( 'ref' 'item' | isComposite ?= 'item' )  
    Usage(this, m)
```

7.6.2.2 Items Graphical Notation

```

kind-keyword (a : ItemDefinition) = 'item' 'def'

kind-keyword (a : AttributeUsage) = 'item'

body-compartment (t : Type) = ... | items-compartment(t)

items-compartment (t : Type) =
    [
        'items'
        items-compartment-text(t)
    ]

items-compartment-text (d : Definition) =
    item-compartment-element-text(d.ownedItem) *

items-compartment-text (u : Usage) =
    item-compartment-element-text(u.nestedItem) *

items-compartment-element-text(i : ItemUsage) =
    compartment-element-text(t)

item-compartment-element-text(i : PartUsage) =
    keyword-element-text(i, "part")

```

7.6.3 Items Abstract Syntax

7.6.3.1 Overview

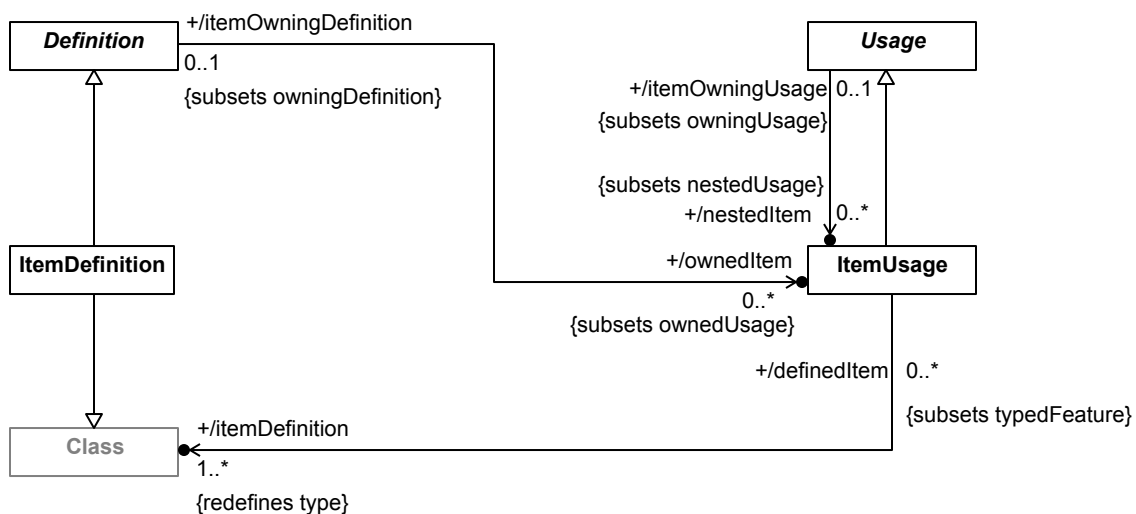


Figure 32. Item Definition and Usage

7.6.3.2 ItemDefinition

Description

An ItemDefinition is a Definition of a Class of things that may be acted on by a system or parts of a system, which do not necessarily perform actions themselves. This includes items that can be exchanged between parts of a system, such as water or electrical signals.

An ItemDefinition must subclass, directly or indirectly, the base ItemDefinition Item from the Systems model library.

General Classes

Class
Definition

Attributes

No attributes.

Operations

No operations.

Constraints

No constraints.

7.6.3.3 ItemUsage

Description

An ItemUsage is a Usage whose type is a Class. Nominally, if the type is an ItemDefinition, an ItemUsage is a Usage of that ItemDefinition within a system. However, other types of Kernel Classes are also allowed, to permit use of Classes from the Kernel Library.

An ItemUsage must subset, directly or indirectly, the base ItemUsage items from the Systems model library.

General Classes

Usage

Attributes

/itemDefinition : Class [1..*] {redefines type}

The Classes that are the types of this ItemUsage. Nominally, these are ItemDefinitions, but other kinds of Kernel Classes are also allowed, to permit use of Classes from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.6.4 Items Semantics

7.7 Parts

7.7.1 Parts Overview

A PartDefinition represents a modular unit of structure such as a system, system component, or external entity that may directly or indirectly interact with the system. A PartDefinition is a kind of ItemDefinition (see [7.6](#)) and, as such, defines a class of part objects with temporal (and possibly spatial) extent. A PartUsage is a kind of ItemUsage.

A part usage is a usage of a part definition. A part usage may be a reference part usage or composite part usage (see [7.6](#)). A part usage may also have multiple definitions. At least one definition must be a part definition, but all other definitions can be either part definitions or item definitions. This allows a part to be treated like an item in some cases (e.g., when an engine under assembly flows through an assembly line) and as a part in other cases (e.g., when an assembled engine is installed in a vehicle).

A system is modeled as a composite part, and its part usages may themselves have further composite structure. The parts of a system may have attributes (see [7.5](#)) that represent different performance, physical and other quality characteristics. The parts may have ports (see [7.8](#)) that define the points at which those parts may be interconnected (see [7.9](#) and [7.10](#)). Parts may also *perform* actions (see [7.12](#)) resulting in items flowing across the connections between them, and *exhibit* states (see [7.13](#)) that enable different actions.

A part can represent any level of abstraction, such as a purely logical component without implementation constraints, or a physical component with a part number, or some intermediate abstraction. Parts can also be used to represent different kinds of system components such as a hardware component, a software component, a facility, an organization, or a user of a system.

7.7.2 Parts Concrete Syntax

7.7.2.1 Parts Textual Notation

```
PartDefinition (m : Membership) : PartDefinition =  
    DefinitionPrefix? ( 'part' 'def' | 'block' )  
    DefinitionDeclaration(this, m) DefinitionBody(m)  
  
PartUsage (m : Membership) : PartUsage =  
    UsagePrefix? 'part' Usage(this, m)  
  
PartFlowUsage (m : Membership) : PartUsage =  
    UsagePrefix? 'ref'? 'part' Usage(this, m)  
  
PartRefUsage (m : Membership) : PartUsage =  
    UsagePrefix? ( 'ref' 'part' | isComposite ?= 'part' )  
    Usage(this, m)
```

7.7.2.2 Parts Graphical Notation

```

kind-keyword (p : PartDefinition) = 'part' 'def' | 'block'

kind-keyword (p : PortUsage) = 'part'

body-compartment (t : Type) = ... | parts-compartment(t)

parts-compartment (t : Type) =
    [
        'parts'
        parts-compartment-text(t)
    ]

parts-compartment-text (d : Definition) =
    compartment-element-text(d.ownedPart)*

parts-compartment-text (u : Usage) =
    compartment-element-text(u.nestedPart)*

```

7.7.3 Parts Abstract Syntax

7.7.3.1 Overview

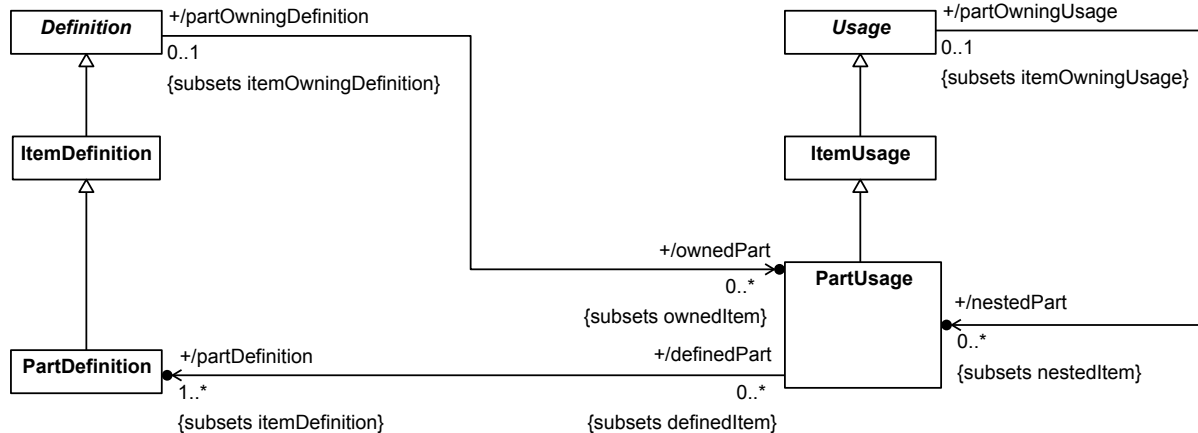


Figure 33. Part Definition and Usage

7.7.3.2 PartDefinition

Description

A PartDefinition is a ItemDefinition of a Class of systems or parts of systems. Note that all parts may be considered items for certain purposes, but not all items are parts that can perform actions within a system.

A PartDefinition must subclass, directly or indirectly, the base PartDefinition Part from the Systems model library.

General Classes

ItemDefinition

Attributes

No attributes.

Operations

No operations.

Constraints

No constraints.

7.7.3.3 PartUsage

Description

A PartUsage is a usage of a PartDefinition to represent a composite part of a system. At least one of the types of the PartUsage must be a PartDefinition.

A PartUsage must subset, directly or indirectly, the base PartUsage parts from the Systems model library.

General Classes

ItemUsage

Attributes

/partDefinition : PartDefinition [1..*] {subsets itemDefinition}

The itemDefinitions of this PartUsage that are PartDefinitions.

Operations

No operations.

Constraints

No constraints.

7.7.4 Parts Semantics

7.8 Ports

7.8.1 Ports Overview

Ports are connection points on parts that enable interactions between parts. A PortDefinition is a kind of Definition element that defines the kind of connection point on a part definition or part usage. PortUsage is a kind of Usage element that is a usage of a port definition.

A part definition or part usage can contain port usages, where each port usage can be connected to one or more port usages on other part usages. These connections enable interactions between part usages that conform to their port usages. Port usages and port definitions can contain nested port usages.

The port definition, like other definition elements, can contain features that specify the kind of interaction that a port usage can support. The port usage can redefine, subset, and/or add to the features of its port definition.

For signal flow, a common feature on a port definition is an item usage that specifies the kind of item that can flow through a port and its direction of flow. For physical interactions, such as when specifying an interface between electrical components, a common pattern is to specify across and through variables for each port. The across and through variables are attributes of the port that are defined as voltage and current quantities respectively (see [7.10](#)).

Each port definition has a *conjugated* port definition that contains features whose direction is reversed from the original port definition. A feature with direction in is changed to direction out, and a feature with direction out is changed to direction in, and a feature with direction in-out is not changed. A conjugate port usage (e.g., conjugate port) is a usage of the conjugated port definition. The conjugate port can represent a compatible port on another part where the only change is the feature direction. A simple example is the specification of two connected ports, where an item flows out of one port and into another port. In this case, the port definition contains an item usage whose direction is out, and its conjugate port definition contains the same item usage, but whose direction is in.

7.8.2 Ports Concrete Syntax

7.8.2.1 Ports Textual Notation

7.8.2.1.1 Port Definitions

```
PortDefinition (m : Membership) : PortDefinition =  
    DefinitionPrefix(this)? 'port' 'def' Definition  
    ownedMembership += ConjugatedPortDefinitionMember(this)  
  
ConjugatedPortDefinitionMember (p : PortDefinition) : Membership =  
    ownedMemberFeature = ConjugatedPortDefinition(p)  
  
ConjugatedPortDefinition (p : PortDefinition) : ConjugatedPortDefinition =  
    ownedPortConjugation = PortConjugation(p)  
  
PortConjugation (p : PortDefinition) : PortConjugation =  
    originalPortDefinition = p
```

7.8.2.1.2 Port Usages

```
PortUsage (m : Membership) : PortUsage =
  UsagePrefix(this)? 'port'
  PortDeclaration(this, m) ValuePart(this)? UsageBody(this)

PartEndUsage (m : Membership) : PortUsage =
  UsagePrefix(this)? 'port'?
  PortDeclaration(this, m) ValuePart(this)? UsageBody(this)

PortDeclaration (p : PortDefinition, m : Membership) =
  Identification(p, m) PortSpecializationPart(p)

PortSpecializationPart (p : Port) =
  PortSpecialization(p) * MultiplicityPart(p)? PortSpecialization(p) *

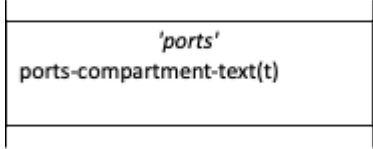
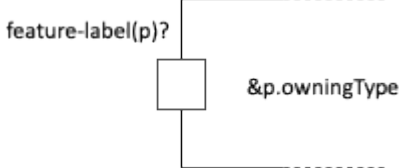
PortSpecialization (p : PortDefinition) =
  PortTypings(p) | Subsettings(p) | Redefinitions(p)

PortTypings (p : PortDefinition) =
  ( ':' | 'defined' 'by' ) p.ownedTyping += PortTyping
  ( ',' p.ownedTyping += PortTyping ) *

PortTyping : FeatureTyping =
  OwnedFeatureTyping | ConjugatedPortTyping

ConjugatedPortTyping : ConjugatedPortTyping =
  '~' originalPortDefinition = [QualifiedName]
```

7.8.2.2 Ports Graphical Notation

```
kind-keyword (p : PortDefinition) = 'port' 'def'
kind-keyword (p : PortUsage) = 'port'
body-compartment (t : Type) = ... | ports-compartment(t)
ports-compartment (t : Type) =
    
ports-compartment-text (d : Definition) =
    compartment-element-text(d.ownedPort)*
ports-compartment-text (u : Usage) =
    compartment-element-text(u.nestedPort)*
boundary-feature-symbol (p : Port, null) =
    
```

Note. A port can be shown using a *boundary feature symbol*, even if it does not have a specified direction (see also [7.4.2.2.4](#) on boundary feature graphical notation in general).

7.8.3 Ports Abstract Syntax

7.8.3.1 Overview

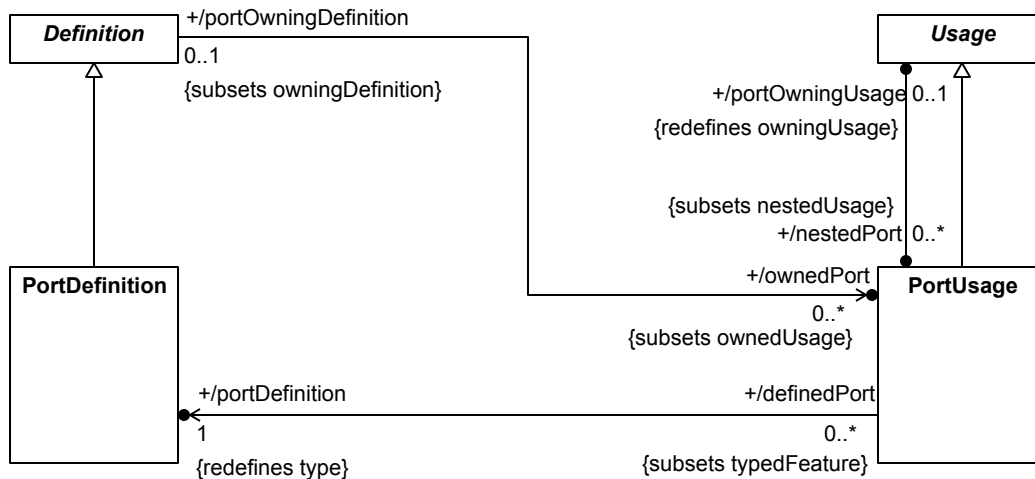


Figure 34. Port Definition and Usage

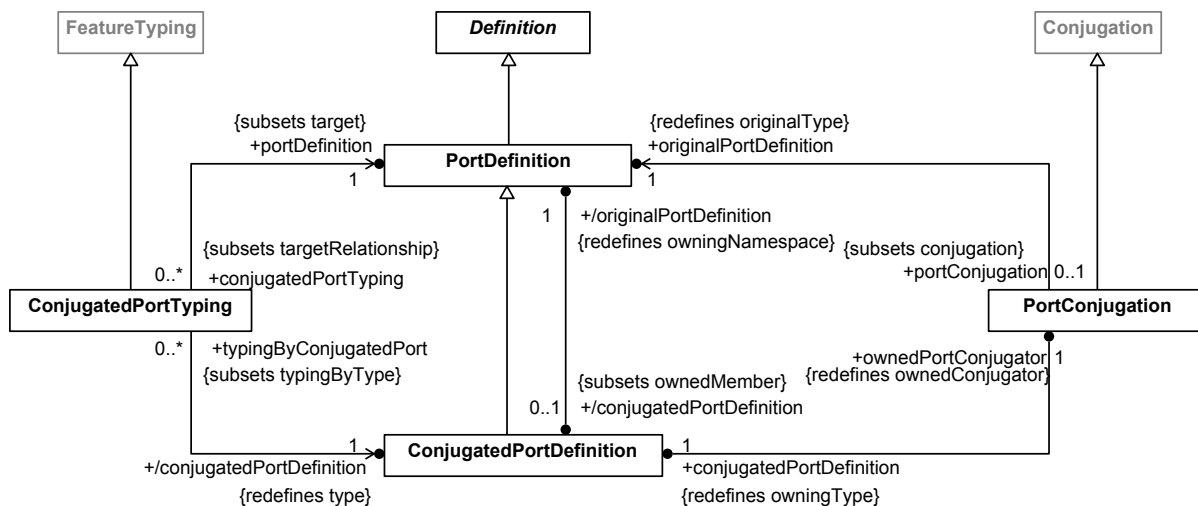


Figure 35. Port Conjugation

7.8.3.2 ConjugatedPortDefinition

Description

A `ConjugatedPortDefinition` is a `PortDefinition` that is a `PortConjugation` of its original `PortDefinition`. That is, a `ConjugatedPortDefinition` inherits all the `features` of the original `PortDefinition`, but input `flows` of the original `PortDefinition` become outputs on the `ConjugatedPortDefinition` and output `flows` of the original `PortDefinition` become inputs on the `ConjugatedPortDefinition`. Every `PortDefinition` has exactly one corresponding `ConjugatedPortDefinition`, whose name is the same as that of the original `PortDefinition`, with the character `~` prepended.

General Classes

PortDefinition

Attributes

`/originalPortDefinition : PortDefinition {redefines owningNamespace}`

The original PortDefinition for this ConjugatedPortDefinition.

`ownedPortConjugator : PortConjugation {redefines ownedConjugator}`

The PortConjugation that is the ownedConjugator of this ConjugatedPortDefinition, linking it its originalPortDefinition.

Operations

No operations.

Constraints

`conjugatedPortDefinitionConjugatedPortDefinitionIsEmpty`

[no documentation]

`conjugatedPortDefinition = null`

`conjugatedPortDefinitionOriginalPortDefinition`

[no documentation]

`originalPortDefinition = ownedPortConjugator.originalPortDefinition`

7.8.3.3 ConjugatedPortTyping

Description

A ConjugatedPortTyping is a FeatureTyping in which the type is derived as the conjugatedPortDefinition of a given PortDefinition. A ConjugatedPortTyping allows a PortUsage to be related directly to a PortDefinition, but to be effectively typed by the conjugation of the referenced PortDefinition.

Note that ConjugatedPortTyping is a *ternary* Relationship, with portDefinition being a third relatedElement, in addition to type and typedFeature from FeatureTyping.

General Classes

FeatureTyping

Attributes

`/conjugatedPortDefinition : ConjugatedPortDefinition {redefines type}`

The conjugatedPortDefinition of the portDefinition of this ConjugatedPortTyping, which is the derived type of the ConjugatedPortTyping considered as a FeatureTyping.

`portDefinition : PortDefinition {subsets target}`

The PortDefinition whose conjugatedPortDefinition is to be the derived type of this ConjugatedPortTyping.

Operations

No operations.

Constraints

conjugatedPortTypingConjugatedPortDefinition

[no documentation]

```
conjugatedPortDefinition = portDefinition.conjugatedPortDefinition
```

7.8.3.4 PortConjugation

Description

A PortConjugation is a Conjugation Relationship between a PortDefinition and its corresponding ConjugatedPortDefinition. As a result of this Relationship, the ConjugatedPortDefinition inherits all the features of the original PortDefinition, but input flows of the original PortDefinition become outputs on the ConjugatedPortDefinition and output flows of the original PortDefinition become inputs on the ConjugatedPortDefinition.

General Classes

Conjugation

Attributes

conjugatedPortDefinition : ConjugatedPortDefinition {redefines owningType}

The ConjugatedPortDefinition that is conjugate to the originalPortDefinition.

originalPortDefinition : PortDefinition {redefines originalType}

The PortDefinition being conjugated.

Operations

No operations.

Constraints

No constraints.

7.8.3.5 PortDefinition

Description

A PortDefinition defines a point at which external entities can connect to and interact with a system or part of a system. Any ownedUsages of a PortDefinition must not be composite.

General Classes

Definition

Attributes

/conjugatedPortDefinition : ConjugatedPortDefinition [0..1] {subsets ownedMember}

The ConjugatedPortDefinition that is conjugate to this PortDefinition.

Operations

No operations.

Constraints

portDefinitionConjugatedPortDefinition

[no documentation]

```
conjugatedPortDefinition = ownedMember->select (oclIsKindOf (ConjugatedPortDefinition))
```

7.8.3.6 PortUsage

Description

A PortUsage is a usage of a PortDefinition. A PortUsage must be owned by a PartDefinition, a PortDefinition, a PartUsage or another PortUsage. Any ownedUsages of a PortUsage must not be composite.

A PortUsage must subset, directly or indirectly, the PortUsage ports from the Systems model library.

General Classes

Usage

Attributes

/portDefinition : PortDefinition {redefines type}

The PortDefinition that is the single type of this PortUsage.

/portOwningUsage : Usage [0..1] {redefines owningUsage}

The Usage in which the nestedPort is nested (if any).

Operations

No operations.

Constraints

No constraints.

7.8.4 Ports Semantics

7.9 Connections

7.9.1 Connections Overview

Connections enable features such as items and parts to be connected in a context. A `ConnectionDefinition` is a kind of KerML Association and also a kind of `PartDefinition`. This enables a connection definition to be a kind of relationship, but at the same time to have structure and other features similar to a `PartDefinition`. A connection definition can associate two or more definition elements. A `ConnectionUsage` is a kind of KerML Connector and a kind of `PartUsage`. A connection usage is a usage of a connection definition that connects usage elements such as items and parts. Connection definitions and connection usages contain connection ends that are bound to their respective connected elements.

A `ConnectionUsage` is a kind of KerML Connector and also a kind of `PartUsage`. A connection usage that connects parts is often a logical connection that abstracts away details of how they are connected. For example, plumbing that includes pipes and fittings may be used to connect a pump and a tank. It is sometimes desired to connect the pump to the tank at a more abstract level without including the plumbing. This is viewed as a logical connection between the pump and the tank. Alternatively, the plumbing can be modeled as a part, sometimes referred to as an interface medium, where the pump connects to the plumbing, and the plumbing connects to the tank.

Since connections are definition and usage elements, they can also have structure. The connection can contain the plumbing either as an owned member, or as a reference, to the plumbing that is owned by a higher level pump-tank system context. In this way, the logical connection without structure can be transformed to a physical connection.

A `BindingConnector` is also a kind of KerML Connector, which is adopted directly for use in SysML and is *not* a kind of `ConnectionUsage`. A binding connector is a special kind of connector that asserts that the values of the features on either end are equal. This is used to bind attributes together to assert two attributes have the same value. A binding connector is also used to bind a reference feature of one context to an owned feature of another context to assert they are the same thing. For example, the steering wheel in a vehicle may be considered part of the interior of the car, while at the same time it is considered part of steering subsystem. The steering wheel can be a composite part usage of the interior, and a reference part usage of the steering subsystem, and these two usages can be bound together with a binding connector to assert that they are the same part. (See [7.2.8](#) for further description of binding connectors.)

Submission Note. Adding a `BindingConnection` specialization of `BindingConnector` for use in SysML is being considered for the revised submission.

7.9.2 Connections Concrete Syntax

7.9.2.1 Connections Textual Notation

7.9.2.1.1 Connection Definitions

```
ConnectionDefinition (m : Membership) : ConnectionDefinition =
  DefinitionPrefix(this)? ('connection' 'def' | 'assoc' 'block' )
  DefinitionDeclaration(this, m) ConnectionBody(this)

ConnectionBody (t : Type) =
  ';' | '{' ConnectionBodyItem(t)* '}'

ConnectionBodyItem (t : Type) =
  DefinitionBodyItem(t)
  | t.ownedFeatureMembership += ConnectionEndMember

ConnectionEndMember : EndFeatureMembership =
  DefinitionMemberPrefix(this) 'end'
  ownedMemberFeature = ConnectionEndElement(this)

ConnectionEndElement (m : Membership) : Usage =
  ReferenceEndUsage(m)
  | ItemRefUsage(m)
  | PartRefUsage(m)
  | PortUsage(m)
  | ActionRefUsage(m)
  | CalculationRefUsage(m)
  | StateRefUsage(m)
```

7.9.2.1.2 Connection Usages

```
ConnectionUsage (m : Membership) : ConnectionUsage =
  UsagePrefix(this)?
  ( ( 'connection' | 'link' ) UsageDeclaration(this, m)
    ( 'connect' ConnectorPart(this) )? )
  | 'connect' ConnectorPart(this)
  )
  ConnectionBody(this)

ConnectorPart (c : ConnectionUsage ) =
  BinaryConnectorPart(c) | NaryConnectorPart(c)

BinaryConnectorPart (c : ConnectionUsage) =
  c.ownedFeatureMembership += ConnectorEndMember 'to'
  c.ownedFeatureMembership += ConnectorEndMember

NaryConnectorPart (c : ConnectionUsage) =
  '(' c.ownedFeatureMembership += ConnectorEndMember ','
  c.ownedFeatureMembership += ConnectorEndMember
  ( ',' c.ownedFeatureMembership += ConnectorEndMember ) * ')'
```

7.9.2.2 Connections Graphical Notation

```
kind-keyword (c : ConnectionDefinition) = 'connection' 'def'
kind-keyword (c : ConnectionUsage) = 'connection'
body-compartment (t : Type) = ... | connections-compartment(t) | ends-compartment(t)
connections-compartment (t : Type) =
    
connections-compartment-text (d : Definition) =
    connections-compartment-element-text(d.ownedConnection)*
connections-compartment-text (u : Usage) =
    connections-compartment-element-text(u.nestedConnection)*
connections-compartment-element-text (c : Connection) =
    compartment-element-text(c)
connection-compartment-element-text (i : Interface) =
    keyword-element-text(i, "interface")
ends-compartment (t : Type) =
    
ends-compartment-text (t : Type) =
    ends-compartment-element-text(t.endFeature)*
end-compartment-element-text (f : Feature) =
    visibility-keyword(f) variation-keyword(f)? abstract-keyword(f)?
    ref-keyword(f)? kind-keyword(f) type-decl-text(f)
    element-graphic(f.ownedAnnotation)*
```

7.9.3 Connections Abstract Syntax

7.9.3.1 Overview

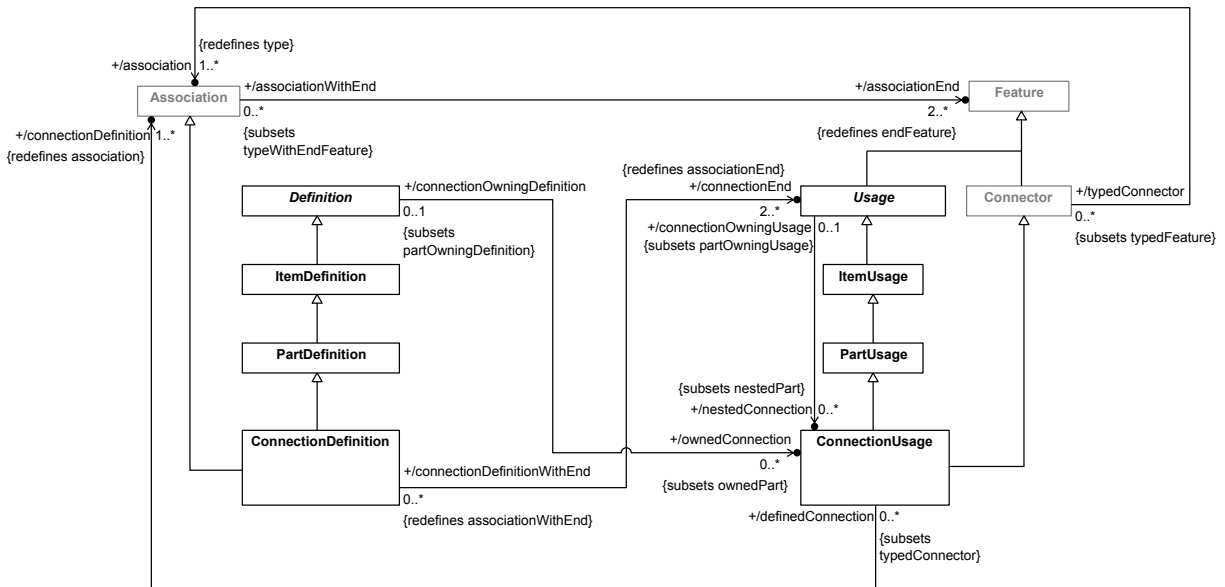


Figure 36. Connection Definition and Usage

7.9.3.2 ConnectionDefinition

Description

A ConnectionDefinition is a PartDefinition that is also an Association, with two or more end features. The associationEnds of a ConnectionUsage must be Usages.

A ConnectionDefinition must subset, directly or indirectly, the base ConnectionDefinition Connection from the Systems model library.

General Classes

Association
PartDefinition

Attributes

/connectionEnd : Usage [2..*] {redefines associationEnd}

The Usages that define the things related by the ConnectionDefinition.

Operations

No operations.

Constraints

No constraints.

7.9.3.3 ConnectionUsage

Description

A `ConnectionUsage` is a `Connector` that is also a `Usage`. Nominally, if its type is a `ConnectionDefinition`, then a `ConnectionUsage` is a `Usage` of that `ConnectionDefinition`, representing a connection between parts of a system. However, other kinds of kernel Associations are also allowed, to permit use of Associations from the Kernel Library (such as the default `BinaryLink`).

A `ConnectionUsage` must subset the base `ConnectionUsage` `connections` from the Systems model library.

General Classes

`Connector`
`PartUsage`

Attributes

`/connectionDefinition : Association [1..*] {redefines association}`

The Associations that are the types of this `ConnectionUsage`. Nominally, these are `ConnectionDefinitions`, but other kinds of Kernel Associations are also allowed, to permit use of Associations from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.9.4 Connections Semantics

7.10 Interfaces

7.10.1 Interfaces Overview

An interface facilitates the specification and reuse of compatible connections between parts. An `InterfaceDefinition` is a kind of `ConnectionDefinition` whose ends are restricted to be port definitions. An `InterfaceUsage` is a kind of `ConnectionUsage` that is usage of an interface definition. The ends of an interface usage are restricted to be port usages. Quite simply, an interface is a connection with ports on either end.

Interface definitions provide an important mechanism for specifying and reusing interfaces. A logical interface may be defined that can then be specialized to represent more specific physical interfaces. For example, an interface can be defined to represent the power interface connection between an appliance and the wall power. The port on one side of the interface can represent the appliance power connection point, and the port on the other side can represent the power outlet connection point. This interface can then be defined, specialized as necessary, and used for connecting many different appliances to wall power.

When modeling physical interactions, the interface definition and interface usage can contain constraints to constrain the values of the attributes on the ports on either end (see [7.8](#)). These attributes are referred to as across and through variables, which are constrained by conservation laws across the interface (e.g., Kirchhoff's Laws). For example, when specifying an interface between electrical components, the across and through variables specified on each port are attributes defined as voltage and current quantities respectively. The attribute values on either port are constrained such that the voltages must be equal, and the sum of the currents must equal zero.

7.10.2 Interfaces Concrete Syntax

7.10.2.1 Interfaces Textual Syntax

7.10.2.1.1 Interface Definitions

```
InterfaceDefinition (m : Membership) : InterfaceDefinition =
    DefinitionPrefix(this) 'interface' 'def'
    DefinitionDeclaration(this, m) InterfaceBody(this)

InterfaceBody (t : Type) =
    ';' | '{' InterfaceBodyItem(t)* '}'

InterfaceBodyItem (t : Type) =
    DefinitionBodyItem(t)
    | t.ownedFeatureMembership += InterfaceEndMember

InterfaceEndMember : EndFeatureMembership =
    DefinitionMemberPrefix(this) 'end'
    ownedMemberFeature = PortEndUsage
```

7.10.2.1.2 Interface Usages

```
InterfaceUsage (m : Membership) : InterfaceUsage =
    UsagePrefix(this) 'interface'
    ( UsageDeclaration(this, m) ( 'connect' ConnectorPart(this) )?
    | ConnectorPart(this)
    )
    InterfaceBody(this)
```

7.10.2.2 Interfaces Graphical Syntax

```
kind-keyword (i : InterfaceDefinition) = 'interface' 'def'

kind-keyword (i : InterfaceUsage) = 'interface'

body-compartment (t : Type) = ... | interfaces-compartment(t)

connections-compartment (t : Type) =
```

'interfaces'
interfaces-compartment-text(t)

```
interfaces-compartment-text (d : Definition) =
    compartment-element-text(d.ownedInterface)*

interfaces-compartment-text (u : Usage) =
    compartment-element-text(u.nestedInterface)*
```

7.10.3 Interfaces Abstract Syntax

7.10.3.1 Overview

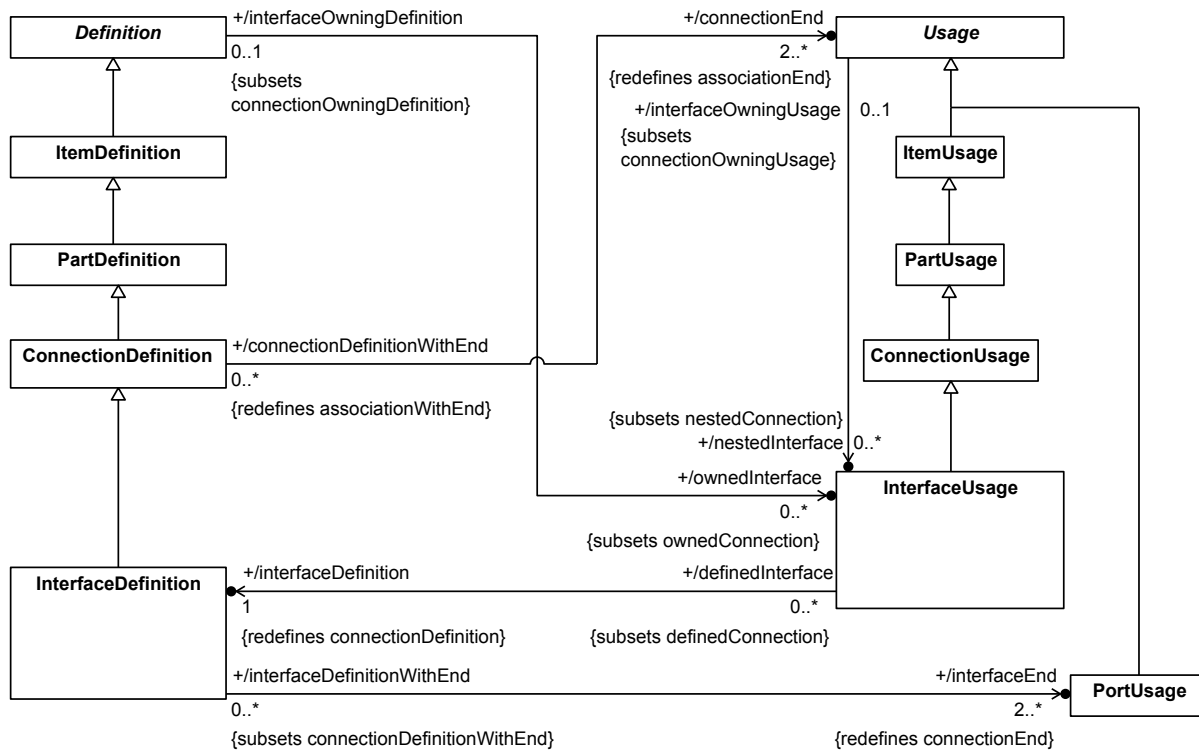


Figure 37. Interface Definition and Usage

The InterfaceUsages that are typed by a certain InterfaceDefinition.

7.10.3.2 InterfaceDefinition

Description

An InterfaceDefinition is a ConnectionDefinition all of whose ends are PortUsages, defining an interface between elements that interact through such ports.

An InterfaceDefinition must subclass, directly or indirectly, the base InterfaceDefinition Interface from the Systems model library.

General Classes

ConnectionDefinition

Attributes

/interfaceEnd : PortUsage [2..*] {redefines connectionEnd}

The PortUsages that are the associationEnds of this InterfaceDefinition.

Operations

No operations.

Constraints

No constraints.

7.10.3.3 InterfaceUsage

Description

An InterfaceUsage is a Usage of an InterfaceDefinition to represent an interface connecting parts of a system through specific ports.

An InterfaceUsage must subset, directly or indirectly, the base InterfaceUsage `interfaces` from the Systems model library.

General Classes

ConnectionUsage

Attributes

/interfaceDefinition : InterfaceDefinition {redefines connectionDefinition}

The InterfaceDefinition that is the single type of this InterfaceUsage.

Operations

No operations.

Constraints

No constraints.

7.10.4 Interfaces Semantics

7.11 Individuals

7.11.1 Individuals Overview

Individuals

An IndividualDefinition is a kind of ItemDefiniton. An individual definition is intended to represent a real or perceived object with a unique identity.

A simple example is the representation of an individual car called Car1 with a vehicle identification number. Car1 is a subclass of the part definition Car. As such, Car1 inherits all the features of Car. Car1 is composed of an individual engine, individual transmission, individual chassis, and 4 individual wheels, each of which is defined by a uniquely identifiable subclass of a part definition.

An IndividualUsage is a kind of Item Usage. An individual usage a usage of an individual definition. For example, the individual definition Car1 can be used in different contexts, such as the usage of Car1 when it is in for service and the usage of Car1 when it is used for normal operations. The usage of Car1 is called car1InService when it is in for service to have its tires rotated. For this usage, car1InService has four wheels that play different roles, including front-left, front-right, rear-left, and rear-right. Each of the four wheels of Car1 is an individual wheel usage defined by an individual wheel definition that is named Wheel1, Wheel2, Wheel3, and Wheel4 respectively. Each individual wheel definition is a subclass of Wheel. When car1_InService enters the shop, the front-left wheel is initially

defined by Wheel1, but after the tires are rotated, the front-left wheel is defined by Wheel2. An individual usage is a role that an individual definition plays for some period of time.

Lifetimes

An Individual definition has a lifetime with a beginning and an end. The beginning of the lifetime occurs when the identity of the individual is established, and the end of the lifetime occurs when the individual loses its identity. For example, the lifetime of a car could begin when it leaves the production-line, or when its vehicle identification number is assigned to the car. Similarly, the lifetime of a car could end when the car is disassembled or demolished. During its lifetime, Car1 can play different roles, such as the car1InService role and the car1InOperation role.

Time Slices

The individual's lifetime can be partitioned into time slices which correspond to some duration of time. These time slices can represent periods or phases of a lifetime, such as the deployment or operational phase. Time slices can be further partitioned into other time slices.

The lifetime and any of its time slices can be actual or projected. For example, the individual car Car1 may be purchased as a used car. Car1 has had an actual lifetime up to that time. A mechanic may perform diagnostics and obtain some measurements, and may estimate the remaining life of the car or its parts based on the measurements. For example, the mechanic may estimate the remaining lifetime of the tires, based on the tread measurements and the estimated tire wear rate.

Snapshots

A time slice with zero time is a snapshot. The start and end snapshot, and intermediate snapshots can be defined for any time slice to represent particular points in time in the individual's lifetime. At a given point in time, the state (i.e., condition) of the individual usage can be specified by the values of its attributes. As an example, the state of car1_inOperation at different points in time can be specified in terms of its acceleration, velocity, and position. In addition, its finite (i.e., discrete) state can be specified at different points in time as off or on, and any nested state such as forward or reverse. The state (i.e., condition) of the car can continue to change over its lifetime, and can be specified as a function of discrete and/or continuous time.

7.11.2 Individuals Concrete Syntax

7.11.2.1 Individuals Textual Notation

7.11.2.1.1 Individual Definitions

```
IndividualDefinition (m : Membership) : IndividualDefinition =
  DefinitionPrefix(m) 'individual' 'def' Definition(this, m)
  ownedMembership += LifeClassMembership(this)

LifeClassMembership (i : IndividualDefinition) : Membership =
  ownedMemberElement = LifeClass(i)

LifeClass (i : IndividualDefinition) : Membership =
  ownedSuperclassing += TargetedSuperclassing(i)
  ownedFeatureMembership += SingletonMultiplicityMember

TargetedSuperclassing (c : Classifier) : Superclassing =
  { general = c }

SingletonMultiplicityMember : FeatureMembership =
  ownedMemberFeature = SingletonMultiplicity

SingletonMultiplicity : MultiplicityRange =
  lowerBound += LiteralZero upperBound += LiteralOne

LiteralZero : LiteralInteger =
  { value = 0 }

LiteralOne : LiteralInteger =
  { value = 1 }
```

7.11.2.1.2 Individual Usages

```
IndividualUsage (m : Membership) : IndividualUsage =
    UsagePrefix(this)? 'individual' Usage(this, m)

IndividualRefUsage (m : Membership) : IndividualUsage =
    UsagePrefix(this)? ( 'ref' 'individual' | isComposite ?= 'individual' )
    Usage(this, m)

TimeSliceUsage (m : Membership) : IndividualUsage =
    UsagePrefix(this)? 'timeslice' Usage(this, m)
    ownedFeatureMembership += TimeSliceFeatureMember(this)

TimeSliceRefUsage (m : Membership) : IndividualUsage =
    UsagePrefix(this)? ( 'ref' 'timeslice' | isComposite ?= 'timeslice' )
    Usage(this, m)
    ownedFeatureMembership += TimeSliceFeatureMember(this)

TimeSliceFeatureMember (i : IndividualUsage) : FeatureMembership =
    ownedMemberFeature = TimeSliceFeature(i)

TimeSliceFeature (i : IndividualUsage) : Feature =
    ownedTyping += FeatureTypingTo(i.individualDefinition)

SnapshotUsage (m : Membership) : IndividualUsage =
    UsagePrefix(this)? 'snapshot' Usage(this, m)
    ownedFeatureMembership += SnapshotFeatureMember(this)

SnapshotRefUsage (m : Membership) : IndividualUsage =
    UsagePrefix(this)? ( 'ref' 'snapshot' | isComposite ?= 'snapshot' )
    Usage(this, m)
    ownedFeatureMembership += SnapshotFeatureMember(this)

SnapshotFeatureMember (i : IndividualUsage) : FeatureMembership =
    ownedMemberFeature = SnapshotFeature(i)

SnapshotFeature (i : Individual) : Feature =
    ownedTyping += FeatureTypingTo(i.individualDefinition)

FeatureTypingTo (t : Type) : FeatureTyping =
    { type = t }
```

7.11.2.1.3 Individual Successions

```
SourceSuccessionMember (t : Type) : FeatureMembership =
  ownedMemberFeature = SourceSuccession(t)
  { t.ownedFeatureMembership += this }

SourceSuccession (t : Type) : Succession =
  'then' ownedFeatureMembership += SourceEndMemberFrom(t)

SourceEndMemberFrom (t : Type) : EndFeatureMembership =
  ConnectorEndMemberFor(sourceFeature(t))

ConnectorEndMemberFor (f : Feature) : EndFeatureMembership =
  ownedMemberFeature = ConnectorEndFor(f)

ConnectorEndFor (f : Feature) : Feature =
  ownedSubsetting += SubsettingTo(f)
  ( ownedFeatureMembership += MultiplicityMember )?

TargetEndMemberFor (f : Feature) : EndFeatureMembership =
  ownedMemberFeature = TargetEndFor(f)

TargetEndFor (f : Feature) : Feature =
  ownedSubsetting += SubsettingTo(f)

SubsettingTo (f : Feature) : Subsetting =
  { subsettingFeature = f }
```

7.11.2.2 Individuals Graphical Notation

```
kind-keyword (a : IndividualDefinition) = 'individual' 'def'
kind-keyword (a : IndividualUsage) = 'individual'
body-compartment (t : Type) = ... | individuals-compartment(t)
individuals-compartment (t : Type) =
    

|                                                                |
|----------------------------------------------------------------|
| <i>'individuals'</i><br><b>individuals-compartment-text(t)</b> |
|----------------------------------------------------------------|


individuals-compartment-text (d : Definition) =
    individuals-compartment-element-text(d.ownedIndividual)*
individuals-compartment-text (u : Usage) =
    individuals-compartment-element-text(u.nestedIndividual)*
individuals-compartment-element-text (i : IndividualUsage) =
    individual-usage-element-text(i, i.isTimeSlice, i.isSnapshot)
individuals-compartment-element-text (i : IndividualUsage, false, false) =
    compartment-element-text(i)
individuals-compartment-element-text (i : IndividualUsage, true, false) =
    keyword-element-text(i, 'timeslice')
individuals-compartment-element-text (i : IndividualUsage, false, true) =
    keyword-element-text(i, 'snapshot')
```

7.11.3 Individuals Abstract Syntax

7.11.3.1 Overview

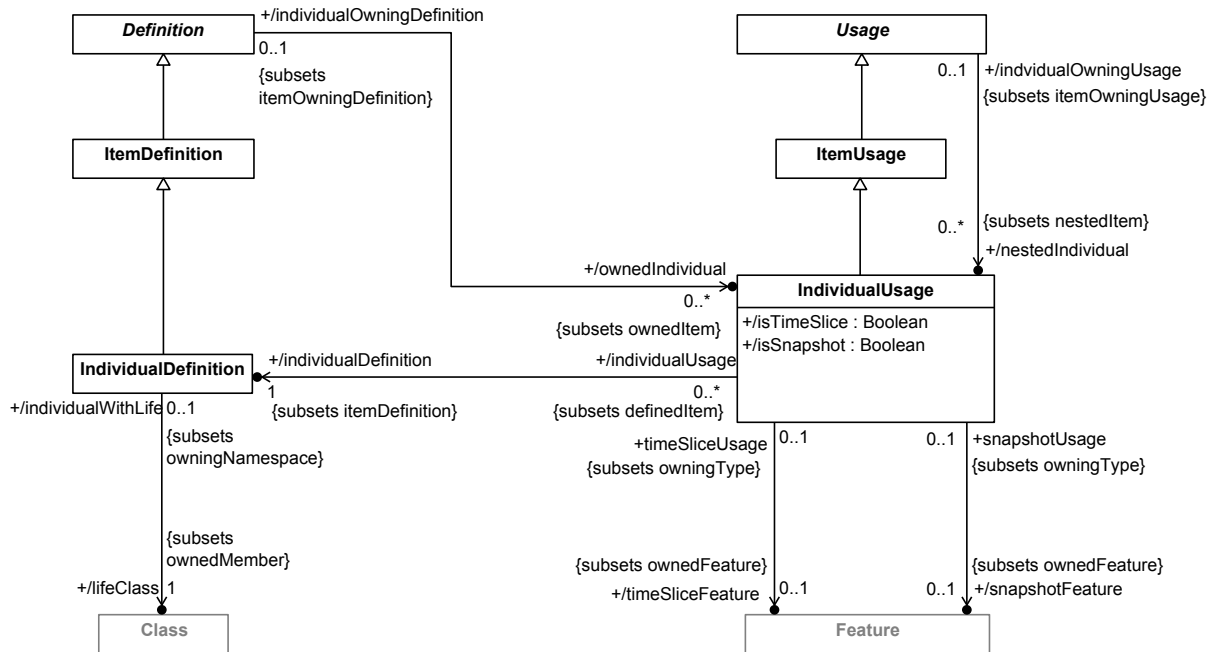


Figure 38. Individual Definition and Usage

7.11.3.2 IndividualDefinition

Description

An IndividualDefinition is an ItemDefinition that is constrained to represent an individual thing. The instances of an IndividualDefinition include all spatial and temporal portions of the individual being represented, but only one of these can be the complete Life of the individual. All other instances must be portions of the "maximal portion" that is single Life instance, capturing the conception that all of the instances represent one individual with a single "identity".

General Classes

ItemDefinition

Attributes

/lifeClass : Class {subsets ownedMember}

An Class that is an ownedMember of this IndividualDefinition, which specializes both the IndividualDefinition and the Base::Life Class from the Kernel Library and has a multiplicity of 0..1. This constrains the IndividualDefinition to have at most one instance that is a complete Life.

Operations

No operations.

Constraints

No constraints.

7.11.3.3 IndividualUsage

Description

An IndividualUsage is a ItemUsage exactly one of whose types is an IndividualDefinition, specifying the usage of the represented individual, or a portion of it, in a certain context.

General Classes

ItemUsage

Attributes

/individualDefinition : IndividualDefinition {subsets itemDefinition}

The one type of the IndividualUsage that is the IndividualDefinition defining the individual thing being represented. (Note that the IndividualUsage may have other types in addition to this that are not IndividualDefinitions.)

/isSnapshot : Boolean

Whether this IndividualUsage represents a temporal portion of the entire spacial extent of an individual at one instance of time, as indicated by whether or not it has a snapshotFeature.

/isTimeSlice : Boolean

Whether this IndividualUsage represents a temporal portion of the entire spacial extent of an individual over some duration of time, as indicated by whether or not it has a timeSliceFeature.

/snapshotFeature : Feature [0..1] {subsets ownedFeature}

An ownedFeature of this IndividualUsage that is a redefinition of the Feature Occurrence::snapshotOf and is typed by the individualDefinition. An IndividualUsage with such a feature is restricted to represent a snapshot of the represented individual.

/timeSliceFeature : Feature [0..1] {subsets ownedFeature}

An ownedFeature of this IndividualUsage that is a redefinition of the Feature Occurrence::timeSliceOf and is typed by the individualDefinition. An IndividualUsage with such a feature is restricted to represent a time slice of the represented individual.

Operations

No operations.

Constraints

individualUsageIsTimeSlice

[no documentation]

isTimeSlice = (timeSliceFeature <> null)

individualUsageIsSnapshotOf

[no documentation]

```
isSnapshot = (snapshotFeature <> Null)
```

7.11.4 Individuals Semantics

7.12 Actions

7.12.1 Actions Overview

Actions

An ActionDefinition is a kind of KerML Behavior (see [7.2.9](#)) and a Definition element that can specify what a part does in terms of its transformation of input items to output items. An ActionUsage is a kind of KerML Step (see [7.2.9](#)) and a Usage of an ActionDefinition. When an action usage executes, it transforms its input item usages to its output item usages. Action definition and action usages describe function-based behavior, which is a kind of causal chain behavior.

Action definitions and action usages follow the same patterns that apply to structural elements. Action definitions and action usages can be decomposed into lower-level action usages to create an action tree, and action usages can be referenced by other actions. In addition, an action definition can be specialized, and an action usage can be subsetted and redefined. This provides enhanced flexibility to modify a hierarchy of action usages to adapt to its context.

A top-level action has a lifetime with a start event and completion event. A child action usage can only execute when its parent action usage is executing.

An action usage can be a feature of a part definition or a part usage, which can perform an action either by reference to an action usage or by an owned action usage. Whether owned or referenced, the action usage that is performed can represent a top action in a hierarchy of action usages.

Control Flows and Control Nodes

Action usages can be connected by control flows and item flows. A basic control flow is a KerML Succession connector, which simply sequences the actions (see [7.2.8](#)). However, a control flow may also have a guard condition, meaning that the succession is only valid if the guard condition evaluates to *true*.

The sequencing of action usages may be further controlled using control nodes, which are special kinds of action usages that impose additional constraints on action sequencing. Control nodes are always connected to other actions usages by incoming and outgoing control flows. The kinds of control nodes include the following.

- A fork node has one incoming control flow and one or more outgoing control flows. The actions connected to the outgoing control flows cannot begin to execute until the action connected to the incoming control flow has completed.
- A join node has one or more incoming control flows and one outgoing control flow. The action connected to the outgoing control flow cannot begin to execute until all the actions connected to the incoming control flows have completed.
- A decision node has one incoming control flow and one or more outgoing control flows. Exactly one of the actions connected to an outgoing control flow can begin to execute after the action connected to the incoming control flow has completed. Which of the downstream actions is executed can be controlled by placing guards on the outgoing control flows.
- A merge node has one or more incoming control flows and one outgoing control flow. The action connected to the outgoing control flow cannot begin to execute until any one of the actions connected to an incoming control flow has completed.

Items Flows and Transfers

In addition to the sequencing of action usages, an output of an action usage can be connected to an input of another action usage using the concept of ItemFlow (see [7.2.10](#)). Each output parameter from one action can be connected to an input parameter of another action by an item flow. The item flow results in a transfer of values from the source output parameter to the target input parameter. A streaming flow is an item flow in which this transfer can be ongoing while both the source and target actions are executing. A succession flow is an item flow that imposes an additional succession constraint, that the transfer of values across the item flow cannot begin until the source action completes execution, and the target action cannot begin executing until the transfer has completed.

Transfers can also be performed using transfer actions. In this case, the source and target of the transfer do not have to be explicitly connected with a flow. Instead, the source of the transfer is specified using a send action from some source part or action, while the target is given by an accept action in some destination part or action (which may be the same as or different than the source). A send action includes an expression that is evaluated to provide the values to be transferred, and it specifies the destination to which those values are to be sent (possibly delegated through a port and across one or more interfaces -- see also [7.8](#) and [7.10](#) on interfaces between ports). An accept action specifies the type of values that can be received by the action. When a send action executing in the source is matched with a compatible accept action executing in the destination, then the transfer of values from the origin to the destination can be completed.

7.12.2 Actions Concrete Syntax

7.12.2.1 Actions Textual Notation

7.12.2.1.1 Action Definitions

```

ActionDefinition (m : Membership) : ActionDefinition =
    DefinitionPrefix(m) ( 'action' 'def' | 'activity' )
    ActionDefinitionDeclaration (this, m) ActionBody(this)

ActionDeclaration (a : ActionDefinition, m : Membership) =
    DefinitionDeclaration (a, m) ParameterList(a)?

ParameterList (t : Type) =
    '(' ( t.ownedFeatureMembership += ParameterMember
        ( ',' t.ownedFeatureMembership += ParameterMember ) * )? ')'

ParameterMember : ParameterMembership =
    ( direction = FeatureDirection )?
    ownedMemberParameter = ParameterDeclaration(this)

ParameterDeclaration(m : Membership) : Feature =
    ReferenceParameterDeclaration(m)
    | ItemParameterDeclaration(m)
    | PartParameterDeclaration(m)
    | ActionParameterDeclaration(m)
    | CalculationParameterDeclaration(m)
    | ConstraintParameterDeclaration(m)

ReferenceParameterDeclaration (m : Membership) : ReferenceUsage =
    'ref'? Identification(this, m) ParameterSpecializationPart(this)

ItemParameterDeclaration (m : Membership) : ItemUsage =
    'item' Identification(this, m) ParameterSpecializationPart(this)

PartParameterDeclaration (m : Membership) : PartUsage =
    'part' Identification(this, m) ParameterSpecializationPart(this)

ActionParameterDeclaration (m : Membership) : ActionUsage =
    'action' Identification(this, m) ParameterSpecializationPart(this)

CalculationParameterDeclaration (m : Membership) : CalculationUsage =
    'calc' Identification(this, m) ParameterSpecializationPart(this)

ConstraintParameterDeclaration (m : Membership) : ConstraintUsage =
    'constraint' Identification(this, m) ParameterSpecializationPart(this)

ParameterSpecializationPart (u : Usage) =
    ParameterSpecialization(u) * MultiplicityPart(u)? ParameterSpecialization(u) *

ParameterSpecialization (u : Usage) =
    TypedBy(u) | Subsets(u) | Redefines(u)

ActionBody (t : Type) =
    ';' | '{' ActionBodyItem(t) * '}'

ActionBodyItem (t : Type) =

```

```

        NonBehaviorBodyItem(t)
    | t.ownedFeatureMembership += ActionBehaviorMember(t)
      ( t.ownedFeatureMembership += ActionTargetSuccessionMember(t) ) *
    | t.ownedFeatureMembership += GuardedSuccessionMember
    | t.ownedImport += PackageImport

NonBehaviorBodyItem (t : Type) =
    t.documentation += OwnedDocumentation
    | t.ownedMembership += NestedDefinitionMember(t)
    | t.ownedMembership += ParameterFlowUsageMember
    | t.ownedMembership += VariantUsageMember
    | t.ownedFeatureMembership += StructureUsageMember
    | t.ownedFeatureMembership += IndividualUsageMember
    | t.ownedFeatureMembership += IndividualSuccessionMember(t)

ActionBehaviorMember (t : Type) : FeatureMembership =
    BehaviorUsageMember
    | InitialNodeMember
    | ActionNodeMember
    | ActionBehaviorSuccessionMember(t)

ParameterFlowUsageMember : ParameterMembership =
    DefinitionMemberPrefix(this) direction = FeatureDirection
    ownedMemberParameter = FlowUsageElement(this)

InitialNodeMember : FeatureMembership =
    DefinitionMemberPrefix(this) 'first' memberFeature = [Qualified Name] ';'

ActionNodeSuccessionMember (t : Type) : FeatureMembership =
    s = SourceSuccessionMember(t)
    ( BehaviorUsageMember | ActionNodeMember )
    TargetEndFor(s.ownedMemberFeature, ownedMemberFeature)

ActionNodeMember : FeatureMembership =
    DefinitionMemberPrefix(this) ownedMemberFeature = ActionNode(this)

ActionTargetSuccessionMember (t : Type) : FeatureMembership =
    DefinitionMemberPrefix(this) ownedMemberFeature = ActionTargetSuccession(t) ';'

GuardedSuccessionMember : FeatureMembership =
    DefinitionMemberPrefix(this) ownedMemberFeature = GuardedSuccession(this) ';'

```

7.12.2.1.2 Action Usages

```
ActionUsage (m : Membership) : ActionUsage =
    UsagePrefix(this)? 'action'
    ActionUsageDeclaration(this, m) ActionBody(this)

ActionFlowUsage (m : Membership) : ActionUsage =
    UsagePrefix(this)? 'ref'? 'action'
    ActionUsageDeclaration(this, m) ActionBody(this)

ActionRefUsage (m : Membership) : ActionUsage =
    UsagePrefix(this)? ( 'ref' 'action' | isComposite ?= 'action' )
    ActionUsageDeclaration(this, m) ActionBody(this)

ActionUsageDeclaration (a : ActionUsage, m : Membership) : ActionUsage =
    UsageDeclaration(this, m) ( ValuePart(this) | ActionUsageParameterList(this) )?

PerformActionUsage (m : Membership) : PerformActionUsage =
    UsagePrefix(this)? 'perform'
    PerformActionUsageDeclaration (this, m) ActionBody(this)

PerformActionUsageDeclaration (a : PerformActionUsage, m : Membership) =
    ( ownedSubsetting += OwnedSubsetting | 'action' Identification(a, m) )
    FeatureSpecializationPart(a)?
    ( ValuePart(a) | ActionUsageParameterList(a) )?

ActionUsageParameterList (f : Feature) =
    '(' ( f.ownedFeatureMembership += ActionUsageParameterMember
        ( ',' f.ownedFeatureMembership += ActionUsageParameterMember )* )? ')'

ActionUsageParameterMember : ParameterMembership =
    ( direction = FeatureDirection )?
    ownedMemberParameter = ActionUsageParameter(this)

ActionUsageParameter (m : Membership) : Usage =
    ParameterDeclaration(m) ValueOrFlowPart(this)?
```

7.12.2.1.3 Action Nodes

```
ActionNode (m : Membership) : ActionUsage =
    SendNode(m) | AcceptNode(m) | ControlNode(m)

AcceptNode (m : Membership) : AcceptActionUsage =
    UsagePrefix(m)? AcceptNodeDeclaration(this, m) ActionBody(this)

AcceptNodeDeclaration (a : AcceptActionUsage, m : Membership) =
    a.ownedFeatureMembership += EmptyParameterMember
    ( 'action' UsageDeclaration(a, m) )?
    'accept' a.ownedFeatureMembership += ItemFeatureMember

SendNode (m : Membership) : SendActionUsage =
    UsagePrefix(this)? SendNodeDeclaration(this, m) ActionBody(this)

SendNodeDeclaration (a : SendActionUsage, m : Membership) =
    ownedFeatureMembership += EmptyParameterMember
    ownedFeatureMembership += EmptyItemFeatureMember
    ( 'action' UsageDeclaration(a, m) )?
    'send' ownedFeatureMembership += OwnedExpressionMember
    'to' ownedFeatureMembership += OwnedExpressionMember

ControlNode (m : Membership) : ControlNode =
    MergeNode(m) | DecisionNode(m) | JoinNode(m) | ForkNode(m)

MergeNode (m : Membership) : MergeNode =
    UsagePrefix(this)? isComposite ?= 'merge' UsageDeclaration(this, m) ';'

DecisionNode (m : Membership) : DecisionNode =
    UsagePrefix(this)? isComposite ?= 'decide' UsageDeclaration(this, m) ';'

JoinNode (m : Membership) : JoinNode =
    UsagePrefix(this)? isComposite ?= 'join' UsageDeclaration(this, m) ';'

ForkNode (m : Membership) : ForkNode =
    UsagePrefix(this)? isComposite ?= 'fork' UsageDeclaration(this, m) ';'

EmptyParameterMember : FeatureMembership =
    ownedMemberFeature = EmptyParameter

EmptyParameter : ReferenceUsage :
    {}
```


7.12.2.1.4 Action Successions

```

ActionTargetSuccession (t : Type) : Feature =
    TargetSuccession(t) | GuardedTargetSuccession(t) | DefaultTargetSuccession(t)

TargetSuccessionMember (t : Type) : FeatureMembership =
    ownedMemberFeature = TargetSuccession(t)

TargetSuccession (t : Type) : Succession =
    ownedFeatureMembership += SourceEndMemberFor(t)
    ownedFeatureMembership += ConnectorEndMember

GuardedTargetSuccession (t : Type) : TransitionUsage =
    ownedFeatureMembership += GuardExpressionMember
    'then' ownedFeatureMembership += TargetSuccessionMember(t)

DefaultTargetSuccession (t : Type) : TransitionUsage =
    'else' ownedFeatureMembership += TargetSuccessionMember(t)

GuardedSuccession (m : Membership) : TransitionUsage =
    'succession' ( UsageDeclaration(this, m) 'first' )?
    f = [Qualified Name]
    ownedFeatureMembership += GuardExpressionMember
    'then' ownedFeatureMembership += TransitionSuccessionMember(f)

```

7.12.2.2 Actions Graphical Notation

7.12.3 Actions Abstract Syntax

7.12.3.1 Overview

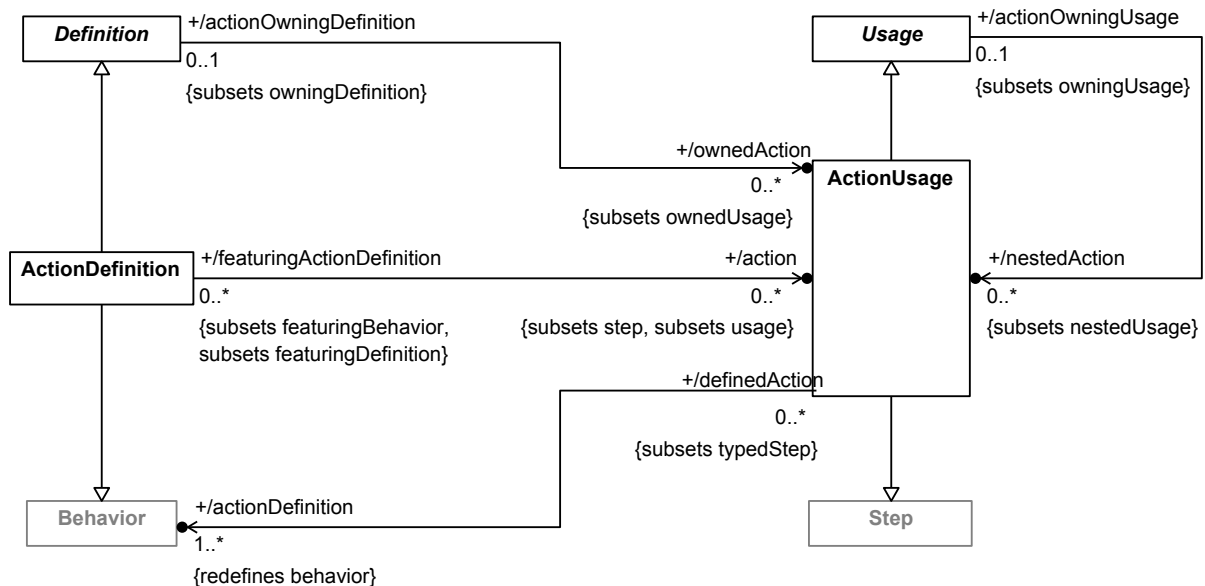


Figure 39. Action Definition and Usage

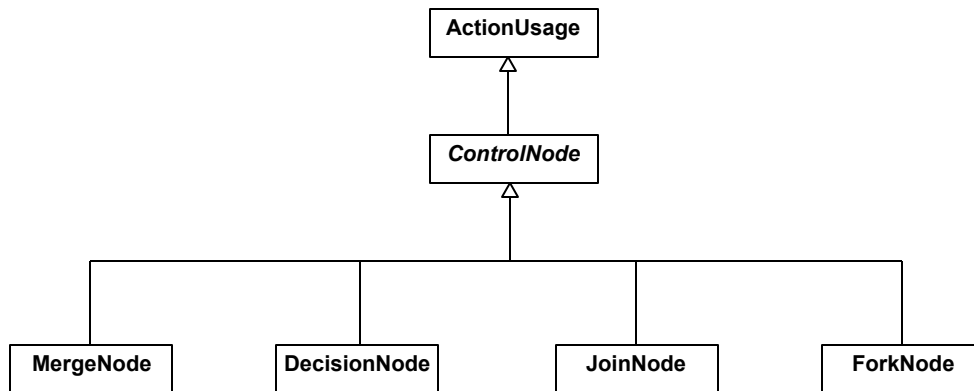


Figure 40. Control Nodes

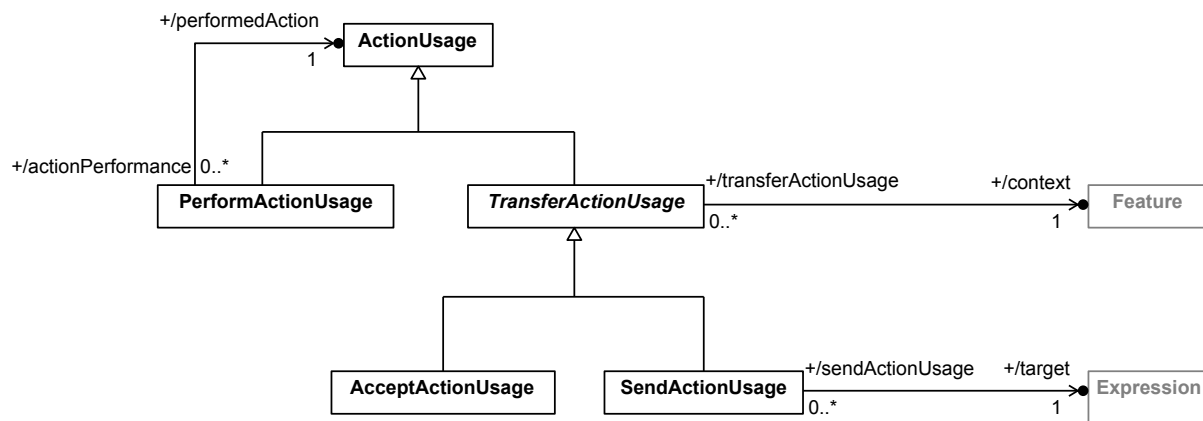


Figure 41. Perform and Transfer Actions

7.12.3.2 AcceptActionUsage

Description

An **AcceptActionUsage** is a **TransferActionUsage** that specifies the acceptance of an incoming **Transfer** from its context.

General Classes

TransferActionUsage

Attributes

No attributes.

Constraints

No constraints.

7.12.3.3 ActionDefinition

Description

An ActionDefinition is a Definition that is also a Behavior that defines an action performed by a system or part of a system.

An ActionDefinition must subclass, directly or indirectly, the base ActionDefinition Action from the Systems model library.

General Classes

Behavior
Definition

Attributes

/action : ActionUsage [0..*] {subsets step, usage}

The ActionUsages that are Steps in this Activity, which define the actions that specify the behavior of the Activity.

Operations

No operations.

Constraints

No constraints.

7.12.3.4 ActionUsage

Description

An ActionUsage is a Usage that is also a Step, and, so, is typed by a Behavior. Nominally, if the type is an ActionDefinition, an ActionUsage is a Usage of that ActionDefinition within a system. However, other kinds of kernel Behaviors are also allowed, to permit use of Behaviors from the Kernel Library.

An ActionUsage (other than a PerformActionUsage owned by a Part) must subset, directly or indirectly, either the base ActionUsage actions from the Systems model library, if it is not a composite feature, or the ActionUsage subactions inherited from its owner, if it is a composite feature.

General Classes

Usage
Step

Attributes

/actionDefinition : Behavior [1..*] {redefines behavior}

The Behaviors that are the types of this ActionUsage. Nominally, these would be ActionDefinitions, but other kinds of Kernel Behaviors are also allowed, to permit use of Behaviors from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.12.3.5 ControlNode

Description

A ControlNode is an ActionUsage that does not have any inherent behavior but provides constraints on incoming and outgoing Succession Connectors that are used to control other Actions.

A ControlNode must be a composite owned feature of an ActionDefinition or ActionUsage, subsetting, directly or indirectly, the ActionUsage `Action : : controls`. This implies that the ControlNode must be typed by ControlAction from the Systems model library, or a subtype of it.

All outgoing Successions from a ControlNode must have source multiplicity of 1..1. All incoming Succession must have target multiplicity of 1..1.

General Classes

ActionUsage

Attributes

No attributes.

Operations

No operations.

Constraints

No constraints.

7.12.3.6 DecisionNode

Description

A DecisionNode is a ControlNode that makes a selection from its outgoing Successions. All outgoing Successions must be must have a target multiplicity of 0..1 and subset the Feature `DecisionAction : : outgoingHBLink`. A DecisionNode may have at most one incoming Succession.

A DecisionNode must subset, directly or indirectly, the ActionUsage `Action : : decisions`, implying that it is typed by DecisionAction from the Systems model library (or a subtype of it).

General Classes

ControlNode

Attributes

No attributes.

Operations

No operations.

Constraints

decisionNodeIncomingSuccession

A DecisionNode may have at most one incoming Succession Connector.

7.12.3.7 ForkNode

Description

A ForkNode is a ControlNode that must be followed by successor Actions as given by all its outgoing Successions. All outgoing Successions must have a target multiplicity of 1..1. A ForkNode may have at most one incoming Succession.

A ForkNode must subset, directly or indirectly, the ActionUsage `Action::forks`, implying that it is typed by ForkAction from the Systems model library (or a subtype of it).

General Classes

ControlNode

Attributes

No attributes.

Operations

No operations.

Constraints

forkNodeIncomingSuccession

A ForkNode may have at most one incoming Succession Connector.

7.12.3.8 JoinNode

Description

A JoinNode is a ControlNode that waits for the completion of all the predecessor Actions given by incoming Successions. All incoming Successions must have a source multiplicity of 1..1. A JoinNode may have at most one outgoing Succession.

A JoinNode must subset, directly or indirectly, the ActionUsage `Action::joins`, implying that it is typed by JoinAction from the Systems model library (or a subtype of it).

General Classes

ControlNode

Attributes

No attributes.

Operations

No operations.

Constraints

joinNodeOutgoingSuccession

A JoinNode may have at most one outgoing Succession Connector.

7.12.3.9 MergeNode

Description

A MergeNode is a ControlNode that asserts the merging of its incoming Successions. All incoming Successions must have a source multiplicity of 0..1 and subset the Feature `MergeAction::incomingHBLink`. A MergeNode may have at most one outgoing Succession.

A MergeNode must subset, directly or indirectly, the ActionUsage `Action::merges`, implying that it is typed by MergeAction from the Systems model library (or a subtype of it).

General Classes

ControlNode

Attributes

No attributes.

Operations

No operations.

Constraints

mergeNodeOutgoingSuccession

A MergeNode may have at most one outgoing Succession Connector.

7.12.3.10 PerformActionUsage

Description

A PerformActionUsage is an ActionUsage that represents the performance of an ActionUsage. The ActionUsage to be performed (which may be the PerformActionUsage itself) is related to the PerformActionUsage by a Subsetting relationship.

If the PerformActionUsage is owned by a Part, then it also subsets the performedAction property of that Part (as defined in the library model for Part), otherwise it subsets either `actions` or `subactions`, as required for a regular ActionUsage.

General Classes

ActionUsage

Attributes

/performedAction : ActionUsage

The ActionUsage to be performed by the PerformedActionUsage. It is the subsettingFeature of the first owned Subsetting Relationship of the PerformedActionUsage.

Constraints

No constraints.

7.12.3.11 SendActionUsage

Description

A SendActionUsage is an ActionUsage that is a Transfer of items sent to a specific target. The context Feature of a SendUsageAction is the result of the target Expression for the SendUsageAction.

General Classes

TransferActionUsage

Attributes

/target : Expression

The target Expression of a SendActionUsage specifies the target Occurrence to which the SendActionUsage transfers items. The result Parameter of the Expression is the context of the SendActionUsage.

Constraints

No constraints.

7.12.3.12 TransferActionUsage

Description

A TransferActionUsage is an ActionUsage that is also an incomingTransfer in a specific context. A TransferActionUsage must not be composite.

A TransferActionUsage must subset, directly or indirectly, the ActionUsage transferActions from the Systems model library. This implies that the TransferActionUsage will be typed by TransferAction from the model library (or a subtype). The TransferActionUsage must bind the context Parameter of the TransferAction to the actual context for the usage.

General Classes

ActionUsage

Attributes

/context : Feature

A Feature specifying the Occurrence of which the TransferActionUsage is an incomingTransfer. The context Feature is the target of a binding connector whose source is the redefinition of TransferAction::context by the TransferActionUsage.

Constraints

No constraints.

7.12.4 Actions Semantics

7.13 States

7.13.1 States Overview

States

A *StateDefinition* is a kind of *ActionDefinition* that defines the conditions under which other actions can execute. A *StateUsage* is a usage of a state definition. State definition and usages are used to describe state-based behavior, where the execution of any particular state is triggered by events.

A state can contain action usages which can only execute while the state is activated. An *entry* action begins execution when the state is activated. A *do* action begins execution after the entry action completes. An *exit* action begins execution after completion of the do action. All actions must execute prior to deactivation of the state.

State definitions and state usages follow the same patterns that apply to structural elements (see [7.4](#)). States can be decomposed into lower-level states to create a hierarchy of state usages, and states can be referenced by other states. In addition, a state definition can be specialized, and a state usage can be subsetting and redefined. This provides enhanced flexibility to modify a state hierarchy to adapt to its context.

A state has a lifetime with a start event and completion event. A child state usage can only be activated when its parent state is activated.

A state usage can be a feature of a part definition or a part usage, which can exhibit a state by referencing the state usage or by containing an owned state usage. Whether owned or referenced, the state usage that the part exhibits can represent a top state in a hierarchy of state usages.

Transitions

State usages can be connected by transition usages, which can activate and deactivate a state usage. The triggering of a transition usage from its source state usage to its target state usage deactivates the source state and activates the target state. If two child state usages are connected by a transition usage, only one of the child states can be activated at any time. If a transition usage does not connect a child state usage to another child state usage, the child state is activated whenever the parent state usage is activated.

A transition usage can be triggered by a triggering event such as when a signal is received, when a change in attribute value is determined, or when a do behavior of a source state of the transition completes its execution. The transition usage can contain a guard condition that must evaluate to true for the transition to occur. In addition, a transition usage may specify an action usage that can begin execution if the transition is triggered, after the source state is deactivated, and must complete execution before the target state is activated.

Submission Note. The transition syntax currently only supports triggering a transition on receipt of a signal. Support for triggering transitions by change and time events will be included in the revised submission. Consideration will also be given to allowing the declaration of transition definitions.

7.13.2 States Concrete Syntax

7.13.2.1 States Textual Notation

7.13.2.1.1 State Definitions

```

StateDefinition (m : Membership) : StateDefinition =
    DefinitionPrefix(this)? 'state' 'def'
    ActionDeclaration (this, m) StateBody(this)

StateBody (t : Type) =
    ';'
    | '{' EntryActionMember(t)?
        ( t.ownedFeatureMembership += DoActionMember )?
        ( t.ownedFeatureMembership += ExitActionMember )?
        StateBodyItem(t)* '}'

EntryActionMember (t : Type) : StateSubactionMembership =
    DefinitionMemberPrefix(this) kind = 'entry' ownedMemberFeature = StateActionUsage
    { t.ownedFeatureMembership += this }
    ( t.ownedFeatureMembership += EntryTransitionMember(this) ) *

DoActionMember : StateSubactionMembership =
    DefinitionMemberPrefix(this) kind = 'do' ownedMemberFeature = StateActionUsage

ExitActionMember : StateSubactionMembership =
    DefinitionMemberPrefix(this) kind = 'exit' ownedMemberFeature = StateActionUsage

EntryTransitionMember (f : Feature) : FeatureMembership :
    DefinitionMemberPrefix(this)
    ( ownedMemberFeature = GuardedTargetSuccession(f)
    | 'then' ownedMemberFeature_comp = TargetTransitionSuccession(f)
    ) ';'

StateActionUsage (m : Membership) : ActionUsage :
    EmptyActionUsage ';'
    | StatePerformActionUsage(m)
    | StateAcceptActionUsage(m)
    | StateSendActionUsage(m)

EmptyActionUsage : ActionUsage =
    {}

StatePerformActionUsage (m : Membership) : PerformActionUsage =
    PerformActionUsageDeclaration(this, m) ActionBody(this)

StateAcceptActionUsage (m : Membership) : AcceptAction =
    AcceptNodeDeclaration(this, m) ActionBody(this)

StateSendActionUsage (m : Membership) : SendAction
    SendNodeDeclaration(this, m) ActionBody(this)

StateBodyItem (t : Type) =
    NonBehaviorBodyItem(t)
    | t.ownedFeatureMembership = BehaviorUsageMember
        ( t.ownedFeatureMembership = TargetTransitionUsageMember(t) ) *
    | t.ownedFeatureMembership += TransitionUsageMember

```

```

TransitionUsageMember : FeatureMembership :
    DefinitionMemberPrefix(this) ownedMemberFeature = TransitionUsage(this) ';'

TargetTransitionUsageMember (t : Type) : FeatureMembership =
    DefinitionMemberPrefix(this) ownedMemberFeature = TargetTransitionUsage(t) ';'

```

7.13.2.1.2 State Usages

```

StateUsage (m : Membership) : StateUsage =
    UsagePrefix(this)? 'state'
    ActionUsageDeclaration(this, m) StateBody(this)

StateFlowUsage (m : Membership) : StateUsage =
    UsagePrefix(this)? 'ref'? 'state'
    ActionUsageDeclaration(this, m) StateBody(this)

StateRefUsage (m : Membership) : ActionUsage =
    UsagePrefix(this)? ( 'ref' 'state' | isComposite ?= 'state' )
    ActionUsageDeclaration(this, m) StateBody(this)

ExhibitStateUsage (m : Membership) : ExhibitStateUsage =
    UsagePrefix(this)? 'exhibit'
    ( ownedSubsetting += OwnedSubsetting | 'state' Identification(this, m) )
    FeatureSpecializationPart(this)?
    ( ValuePart(this) | ActionUsageParameterList(this) )?
    StateBody(this)

```

7.13.2.1.3 Transition Usages

```
TransitionUsage (m : Membership) : TransitionUsage =
  'transition' ( UsageDeclaration(this, m) 'first' )?
  f = [QualifiedName]
  ( ownedFeatureMembership += TriggerActionMember )?
  ( ownedFeatureMembership += GuardExpressionMember )?
  ( ownedFeatureMembership += EffectBehaviorMember )?
  'then' ownedFeatureMembership += TransitionSuccessionMember(f)

TargetTransitionUsage (t : Type) : TransitionUsage =
  ( ownedFeatureMembership += TriggerActionMember )?
  ( ownedFeatureMembership += GuardExpressionMember )?
  ( ownedFeatureMembership += EffectBehaviorMember )?
  'then' ownedFeatureMembership_comp += TargetSuccessionMember(t)

TriggerActionMember : TransitionFeatureMembership =
  'accept' { kind = 'trigger' } ownedMemberFeature = TriggerAction

TriggerAction : AcceptActionUsage =
  ownedFeatureMembership += EmptyParameterMember
  ownedFeatureMembership += ItemFeatureMember

GuardExpressionMember : TransitionFeatureMembership =
  'if' { kind = 'guard' } ownedMemberFeature = OwnedExpression

EffectBehaviorMember : TransitionFeatureMembership =
  'do' { kind = 'effect' } ownedMemberFeature = EffectBehaviorUsage

EffectBehaviorUsage : ActionUsage =
  EmptyActionUsage
  | TransitionPerformActionUsage(m)
  | TransitionAcceptActionUsage(m)
  | TransitionSendActionUsage(m)

TransitionPerformActionUsage (m : Membership) : PerformActionUsage =
  PerformActionDeclaration(this, m) ( '{' ActionBodyItem* '}' )?

TransitionAcceptActionUsage (m : Membership) : AcceptActionUsage =
  AcceptNodeDeclaration(this, m) ( '{' ActionBodyItem* '}' )?

TransitionSendActionUsage (m : Membership) : SendActionUsage =
  SendNodeDeclaration(this, m) ( '{' ActionBodyItem* '}' )?

TransitionSuccessionMember (f : Feature) : FeatureMembership =
  ownedMemberFeature = TransitionSuccession(f)

TransitionSuccession (f : Feature) : Succession =
  ownedFeatureMembership += ConnectorEndMemberFor(f)
  ownedFeatureMembership += ConnectorEndMember
```

7.13.2.2 States Graphical Notation

7.13.3 States Abstract Syntax

7.13.3.1 Overview

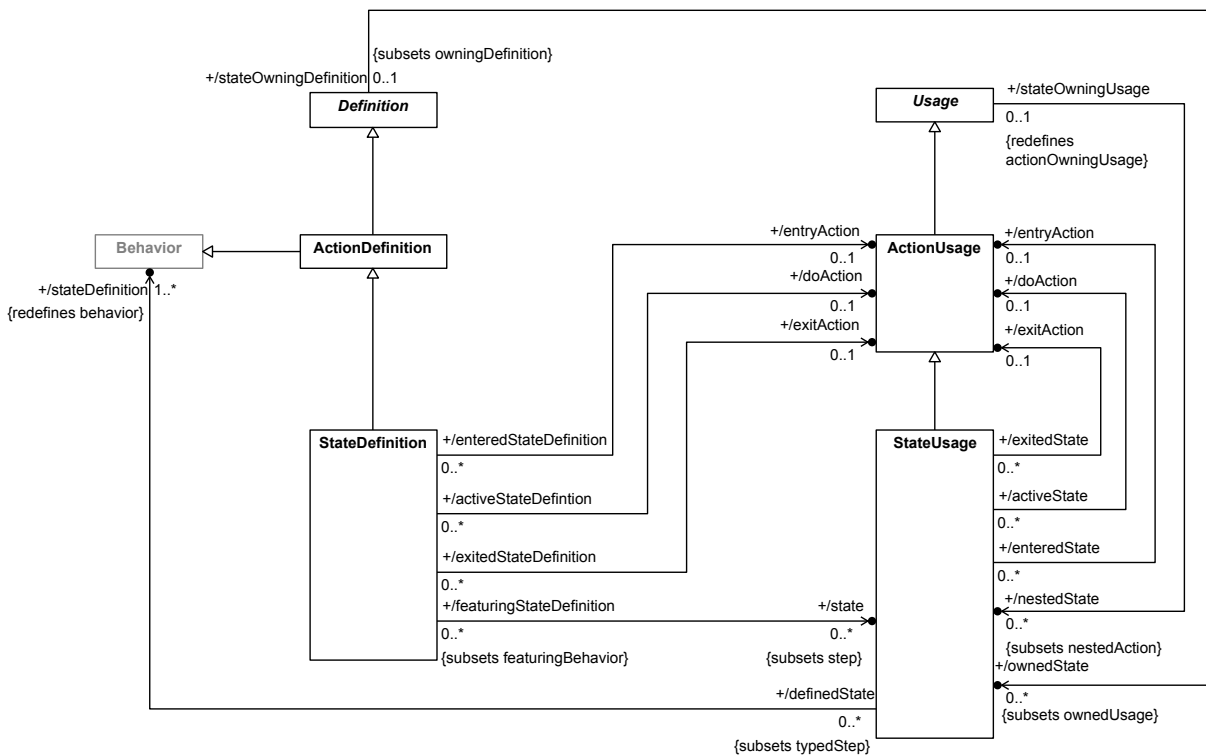


Figure 42. State Definition and Usage

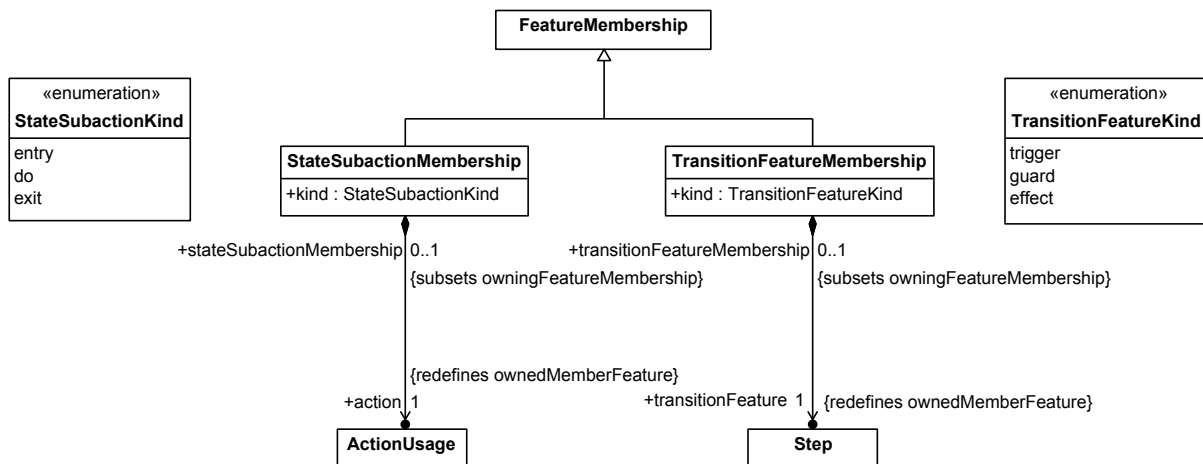


Figure 43. State Membership

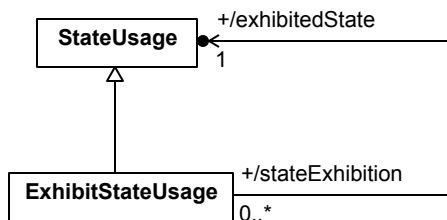


Figure 44. State Exhibition

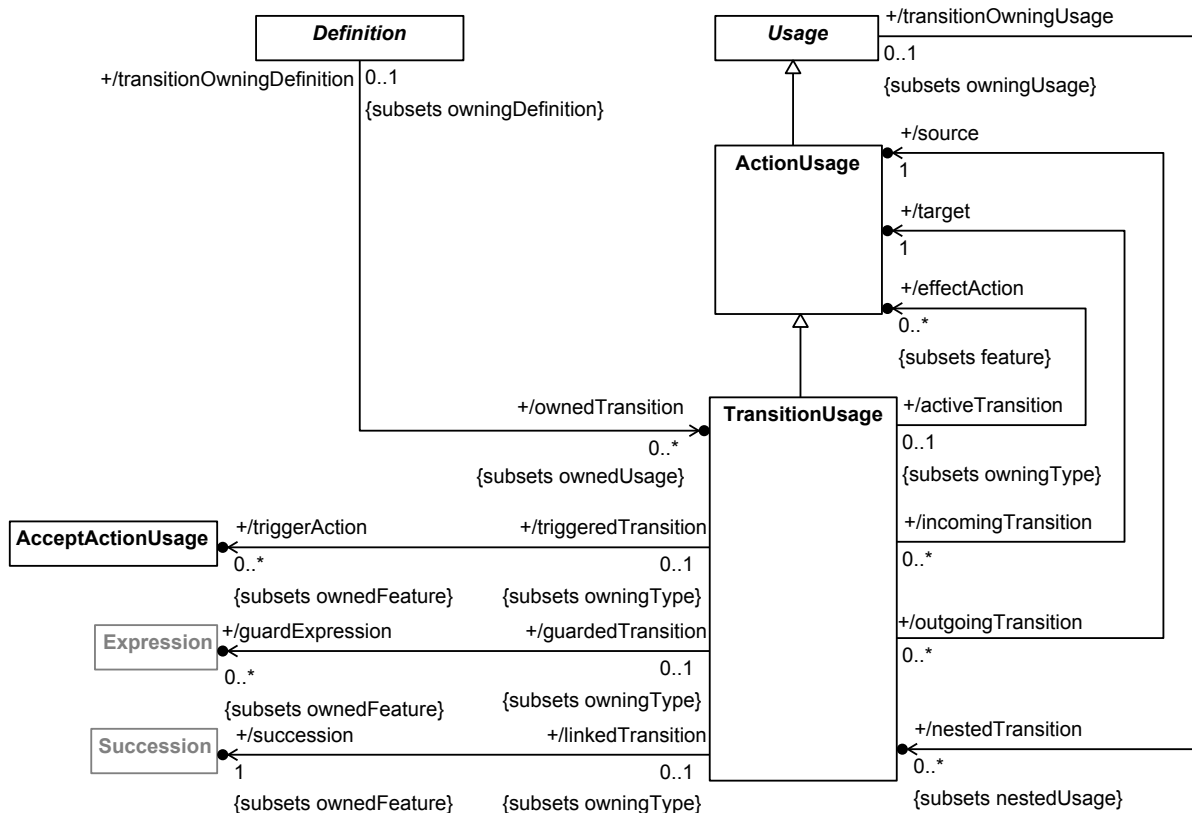


Figure 45. Transition Usage

7.13.3.2 ExhibitStateUsage

Description

An ExhibitStateUsage is a StateUsage that represents the exhibiting of a StateUsage. The StateUsage to be exhibited (which may be the ExhibitStateUsage itself) is related to the ExhibitStateUsage by a Subsetting Relationship.

If the ExhibitStateUsage is owned by a Part, then it also subsets the exhibitedStates property of that Part (as defined in the library model for Part), otherwise it subsets either states or substates, as required for a regular StateUsage.

General Classes

StateUsage

Attributes

/exhibitedState : StateUsage

The StateUsage to be exhibited by the ExhibitStateUsage. It is the `subsettedFeature` of the first owned Subsetting Relationship of the ExhibitStateUsage.

Operations

No operations.

Constraints

No constraints.

7.13.3.3 StateSubactionKind

Description

A StateSubactionKind indicates whether the `action` of a StateSubactionMembership is an entry, do or exit action.

General Classes

No general classes.

Literal Values

do

Indicates that a subaction of a StateUsage is a do action.

entry

Indicates that a subaction of a StateUsage is an entry action.

exit

Indicates that a subaction of a StateUsage is an exit action.

7.13.3.4 StateSubactionMembership

Description

A StateSubactionMembership is a FeatureMembership for an entry, do or exit ActionUsage of a StateDefinition or StateUsage. The `ownedMemberFeature` of a StateSubactionMembership must be an ActionUsage.

General Classes

FeatureMembership

Attributes

action : ActionUsage {redefines ownedMemberFeature}

The ActionUsage that is the `ownedMemberFeature` of this StateSubactionMembership.

kind : StateSubactionKind

Whether this StateSubactionMembership is for an entry, do or exit ActionUsage.

Operations

No operations.

Constraints

No constraints.

7.13.3.5 StateDefinition

Description

A StateDefinition is the Definition of the Behavior of a system or part of a system in a certain state condition.

A State Definition must subclass, directly or indirectly, the base StateDefinition StateAction from the Systems model library.

A StateDefinition may be related to up to three of its ownedFeatures by StateBehaviorMembership Relationships, all of different kinds, corresponding to the entry, do and exit actions of the StateDefinition.

General Classes

ActionDefinition

Attributes

/doAction : ActionUsage [0..1]

The ActionUsage of this StateDefinition to be performed while in the state defined by the StateDefinition. This is derived as the owned ActionUsage related to the StateDefinition by a StateSubactionMembership with kind = do.

/entryAction : ActionUsage [0..1]

The ActionUsage of this StateDefinition to be performed on entry to the state defined by the StateDefinition. This is derived as the owned ActionUsage related to the StateDefinition by a StateSubactionMembership with kind = entry.

/exitAction : ActionUsage [0..1]

The ActionUsage of this StateDefinition to be performed on exit from the state defined by the StateDefinition. This is derived as the owned ActionUsage related to the StateDefinition by a StateSubactionMembership with kind = exit.

/state : StateUsage [0..*] {subsets step}

The StateUsages that are the steps of the StateDefinition, which specify the discrete states in the Behavior defined by the StateDefinition.

Operations

No operations.

Constraints

No constraints.

7.13.3.6 StateUsage

Description

A StateUsage is an ActionUsage that is nominally the Usage of a StateDefinition. However, other kinds of kernel Behaviors are also allowed as types, to permit use of Behaviors from the Kernel Library.

A StateUsage (other than an ExhibitStateUsage owned by a Part) must subset, directly or indirectly, either the base StateUsage `stateActions` from the Systems model library, if it is not a composite feature, or the StateUsage `substates` inherited from its owner, if it is a composite feature.

A StateUsage may be related to up to three of its ownedFeatures by StateBehaviorMembership Relationships, all of different kinds, corresponding to the entry, do and exit actions of the StateUsage.

General Classes

ActionUsage

Attributes

/doAction : ActionUsage [0..1]

The ActionUsage of this StateUsage to be performed while in the state specified by the StateUsage. This is derived as the owned ActionUsage related to the StateDefinition by a StateSubactionMembership with `kind = do`.

/entryAction : ActionUsage [0..1]

The ActionUsage of this StateUsage to be performed on entry to the state specified by the StateUsage. This is derived as the owned ActionUsage related to the StateDefinition by a StateSubactionMembership with `kind = entry`.

/exitAction : ActionUsage [0..1]

The ActionUsage of this StateUsage to be performed on exit from the state specified by the StateUsage. This is derived as the owned ActionUsage related to the StateDefinition by a StateSubactionMembership with `kind = exit`.

/stateDefinition : Behavior [1..*] {redefines behavior}

The Behaviors that are the types of this StateUsage. Nominally, these would be StateDefinitions, but non-Activity Behaviors are also allowed, to permit use of Behaviors from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.13.3.7 TransitionFeatureKind

Description

A TransitionActionKind indicates whether the `transitionFeature` of a TransitionFeatureMembership is a trigger, guard or effect.

General Classes

No general classes.

Literal Values

effect

Indicates that a member Step of a TransitionUsage represents an effect.

guard

Indicates that a member Expression of a TransitionUsage represents a guard.

trigger

Indicates that a member Transfer of a TransitionUsage represents a trigger.

7.13.3.8 TransitionFeatureMembership

Description

A TransitionFeatureMembership is a FeatureMembership for a trigger, guard or effect of a TransitionUsage. The `ownedMemberFeature` must be a Step. For a trigger, the `ownedMemberFeature` must more specifically be a Transfer, while for a guard it must be an Expression with a result type of Boolean.

General Classes

FeatureMembership

Attributes

`kind` : TransitionFeatureKind

Whether this TransitionFeatureMembership is for a trigger, guard or effect.

`transitionFeature` : Step {redefines `ownedMemberFeature`}

The Step that is the `ownedMemberFeature` of this TransitionFeatureMembership.

Operations

No operations.

Constraints

No constraints.

7.13.3.9 TransitionUsage

Description

A TransitionUsage is an ActionUsage that is a behavioral Step representing a transition between ActionUsages or StateUsages.

A TransitionUsage must subset, directly or indirectly, the base TransitionUsage `transitionActions`, if it is not a composite feature, or the TransitionUsage `subtransitions` inherited from its owner, if it is a composite feature.

A TransitionUsage may be related to some of its `ownedFeatures` using TransitionFeatureMembership Relationships, corresponding to the triggers, guards and effects of the TransitionUsage.

General Classes

ActionUsage

Attributes

`/effectAction : ActionUsage [0..*] {subsets feature}`

The ActionUsages that define the effects of this TransitionUsage, derived as the `ownedFeatures` of this TransitionUsage related to it by a TransitionFeatureMembership with `kind = effect`.

`/guardExpression : Expression [0..*] {subsets ownedFeature}`

The Expressions that define the guards of this TransitionUsage, derived as the `ownedFeatures` of this TransitionUsage related to it by a TransitionFeatureMembership with `kind = guard`.

`/source : ActionUsage`

The source ActionUsage of this TransitionUsage, derived as the `source` of the `succession` for the TransitionUsage.

`/succession : Succession {subsets ownedFeature}`

The Succession that is the `ownedFeature` of this TransitionUsage that redefines `TransitionPerformance::transitionLink`.

`/target : ActionUsage`

The target ActionUsage of this TransitionUsage, derived as the `target` of the `succession` for the TransitionUsage.

`/triggerAction : AcceptActionUsage [0..*] {subsets ownedFeature}`

The AcceptActionUsages that define the triggers of this TransitionUsage, derived as the `ownedFeatures` of this TransitionUsage related to it by a TransitionFeatureMembership with `kind = trigger`.

Operations

No operations.

Constraints

No constraints.

7.13.4 States Semantics

7.14 Calculations

7.14.1 Calculations Overview

A CalculationDefinition is a kind of ActionDefinition (see [7.12](#)) one of whose parameters is always a designated output parameter called the result. The calculation definition specifies a reusable computation that returns the result. A CalculationUsage is a usage of a calculation definition.

Calculations are often used to define mathematical functions that have multiple inputs and return one output. The inputs are ordered in a parameter list, and the output is designated as a result. Such a calculation should be stateless in that a set of inputs always produce the same output. The calculation definition and usage can contain one or more equations that define the computation to be carried, but must return a single result.

A CalculationDefinition is also a KerML Function and a CalculationUsage is a KerML Expression (see [7.2.11](#)). This allows a calculation definition to also be invoked using the notation of an invocation expression (see [7.2.12](#)).

7.14.2 Calculations Concrete Syntax

7.14.2.1 Calculations Textual Notation

7.14.2.1.1 Calculation Definitions

```
CalculationDefinition (m : Membership) : CalculationDefinition =
    DefinitionPrefix(this)? 'calc' 'def' DefinitionDeclaration(this, m)
    ( ParameterList(this) ReturnParameterPart(this)? )?
    ( CalculationBody(this)
    | '=' ownedFeatureMembership += ResultExpressionMember ';'
    )

CalculationDeclaration (c : CalculationDefinition, m : Membership) =
    DefinitionDeclaration(this, m) ( ParameterList(this) ReturnParameterPart(this)? )?

ReturnParameterPart (t : Type) =
    t.ownedFeatureMembership += ReturnParameterMember

ReturnParameterMember : ReturnParameterMembership =
    'return'? ownedMemberParameter = ParameterDeclaration(this)

CalculationBody (t : Type) =
    ';'
    | '{' CalculationBodyItem(t)*
      ( t.ownedFeatureMembership += ResultExpressionMember )?
    '}'

CalculationBodyItem (t : Type) =
    ActionBodyItem(t)
    | t.ownedFeatureMembership += ReturnParameterFlowUsageMember

ReturnParameterFlowUsageMember : ReturnParameterMembership =
    DefinitionMemberPrefix(this)? 'return' ownedMemberParameter = FlowUsageElement

ResultExpressionMember : ResultExpressionMembership =
    DefinitionMemberPrefix(this)? ownedResultExpression = OwnedExpression
```

7.14.2.1.2 Calculation Usages

```

CalculationUsage (m : Membership) : CalculationUsage =
  UsagePrefix? 'calc'
  CalculationUsageDeclaration(this, m) CalculationBody(this)

CalculationFlowUsage (m : Membership) : CalculationUsage =
  UsagePrefix? 'ref'? 'calc'
  CalculationUsageDeclaration(this, m) CalculationBody(this)

CalculationRefUsage (m : Membership) : CalculationUsage =
  UsagePrefix? ( 'ref' 'calc' | isComposite ?= 'calc' )
  CalculationUsageDeclaration(this, m) CalculationBody(this)

CalculationUsageDeclaration (u : Usage, m : Membership) =
  UsageDeclaration(this, m) CalculationParameterPart(u)?

CalculationParameterPart (u : Usage) =
  ValuePart(u)
  | ActionUsageParameterList(u)
  ( ownedFeatureMembership += CalculationReturnParameterMember )?

CalculationReturnParameterMember : ReturnParameterMembership =
  'return'? ownedMemberParameter = ActionUsageParameter(this)

```

7.14.2.2 Calculations Graphical Notation

7.14.3 Calculations Abstract Syntax

7.14.3.1 Overview

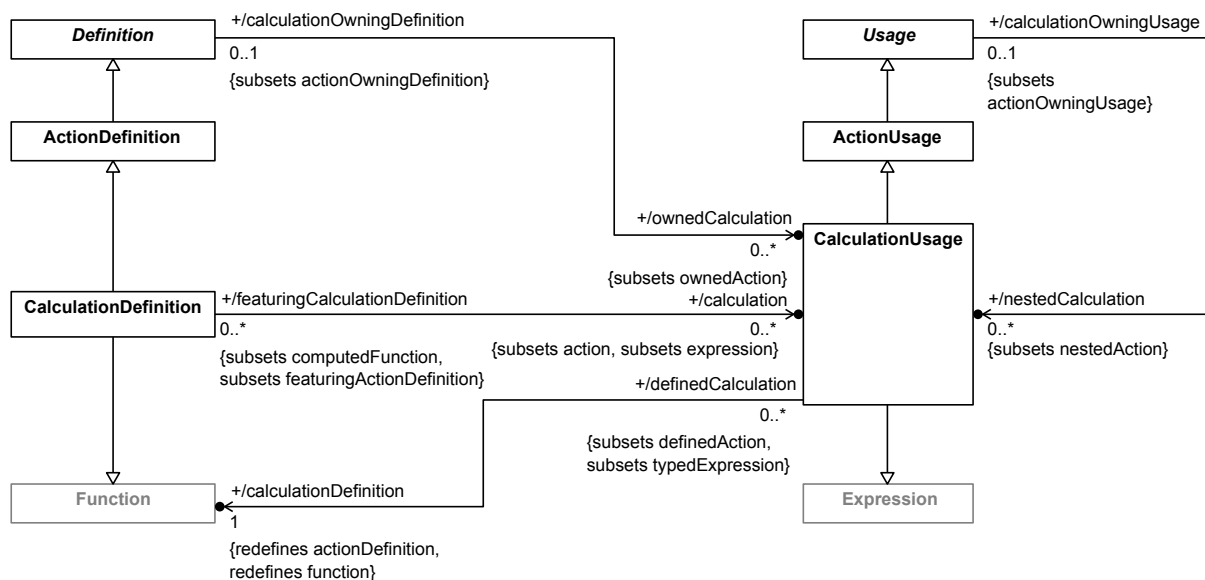


Figure 46. Calculation Definition and Usage

7.14.3.2 CalculationDefinition

Description

A CalculationDefinition is an ActionDefinition that also defines a Function producing a `result`.

A CalculationDefinition must subclass, directly or indirectly, the base CalculationDefinition `Calculation` from the Systems model library.

General Classes

ActionDefinition
Function

Attributes

/calculation : CalculationUsage [0..*] {subsets action, expression}

The CalculationUsage that are `actions` in this CalculationDefinition.

Operations

No operations.

Constraints

No constraints.

7.14.3.3 CalculationUsage

Description

A CalculationUsage is an ActionUsage that is also an Expression, and, so, is typed by a Function. Nominally, if the type is a CalculationDefinition, a CalculationUsage is a Usage of that CalculationDefinition within a system. However, other kinds of kernel Functions are also allowed, to permit use of Functions from the Kernel Library.

A CalculationUsage must subset, directly or indirectly, either the base CalculationUsage `calculations` from the Systems model library, if it is not a composite feature, or the CalculationUsage `subcalculations` inherited from its owner, if it is a composite feature.

General Classes

Expression
ActionUsage

Attributes

/calculationDefinition : Function {redefines function, actionDefinition}

The Function that is the type of this CalculationUsage. Nominally, this would be a CalculationDefinition, but a kernel Function is also allowed, to permit use of Functions from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.14.4 Calculations Semantics

7.15 Constraints

7.15.1 Constraints Overview

A `ConstraintDefinition` is a KerML Predicate (see [7.2.11](#)) and a kind of Definition (see [7.4](#)). A constraint definition is a logical predicate that is a parameterized Boolean-valued expression used to constrain features. A simple example is $\{x < y\}$, which is a Boolean-valued expression in which the parameters x and y are related by the relational operator $<$. Such an expression evaluates to either true or false depending on the values of its parameters. For the constraint $\{x < y\}$, if x is 3 and y is 5, then the Boolean expression evaluates to true. In the general case, the expression used to define a constraint can be arbitrarily complicated, as long as the overall expression returns a Boolean value.

A `ConstraintUsage` is a kind of Usage element. A constraint usage is a usage of a constraint definition. The parameters of a constraint usage may be bound to specific features whose values can be constrained by the constraint expression. For the constraint expression $\{x < y\}$, the constraint usage may bind x to the diameter of a bolt and bind y to the diameter of a hole that the bolt must fit into. This constraint can then be evaluated to be true or false.

For a given set of parameter values, a constraint usage is satisfied if its expression evaluates to true and *violated* otherwise. In general, a constraint may be satisfied sometimes and violated other times. However, a constraint usage can also be *asserted* to be true, which requires that the assert constraint *always* be satisfied for the model to be valid. Constraints associated with the laws of physics, for example, should be asserted to be true, because they cannot be violated in any valid model of the real world. However, the constraint $\{\text{fuel} > 0\}$ may be evaluated to be false if the fuel equals zero $\{\text{fuel} == 0\}$, but this is still a valid model.

7.15.2 Constraints Concrete Syntax

7.15.2.1 Constraints Textual Notation

```
ConstraintDefinition (m : Membership) : ConstraintDefinition =
    DefinitionPrefix(this)? 'constraint' 'def'
    ConstraintDeclaration(this, m) CalculationBody(this)

ConstraintDeclaration (c : ConstraintDefinition, m : Membership) =
    DefinitionDeclaration(this, m) ParameterList(this)?

ConstraintUsage (m : Membership) : ConstraintUsage =
    UsagePrefix(this)? 'constraint'
    CalculationDeclaration(this, m) CalculationBody(this)

ConstraintFlowUsage (m : Membership) : ConstraintUsage =
    UsagePrefix(this)? 'ref'? 'constraint'
    CalculationDeclaration(this, m) CalculationBody(this)

ConstraintRefUsage (m : Membership) : ConstraintUsage =
    UsagePrefix(this)? ( 'ref' 'constraint' | isComposite ?= 'constraint' )
    CalculationDeclaration(this, m) CalculationBody(this)

AssertConstraintUsage (m : Membership) : AssertConstraintUsage =
    UsagePrefix(this)? 'assert'
    ( ownedSubsetting += OwnedSubsetting | 'constraint' Identification(this, m) )
    FeatureSpecializationPart(this)?
    CalculationParameterPart(this) CalculationBody(this)
```

7.15.2.2 Constraints Graphical Notation

7.15.3 Constraints Abstract Syntax

7.15.3.1 Overview

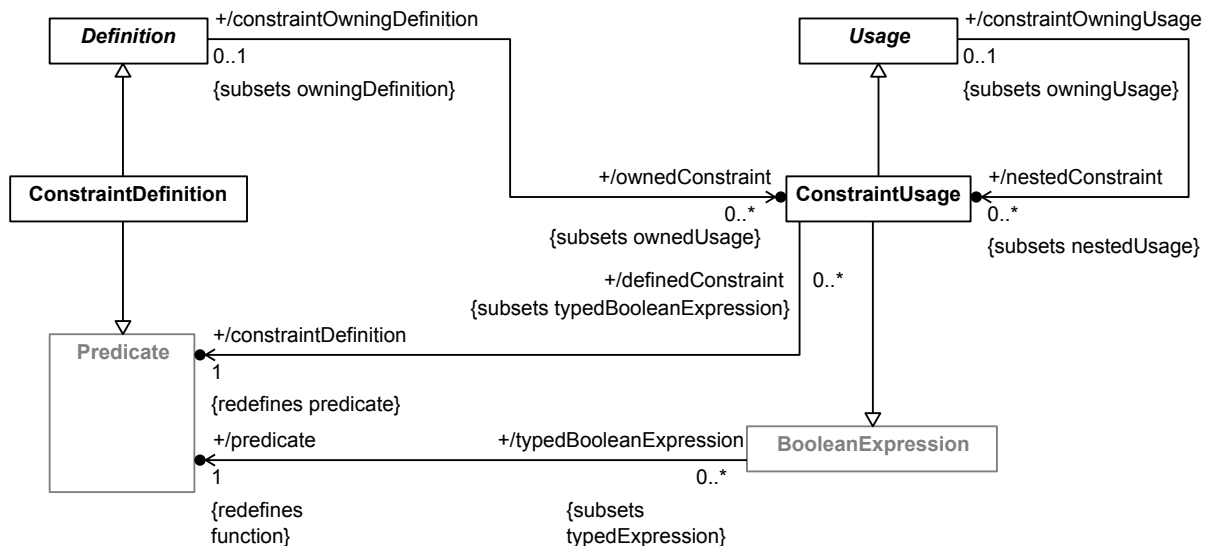


Figure 47. Constraint Definition and Usage

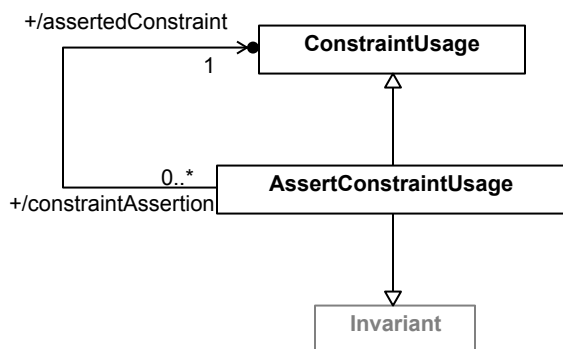


Figure 48. Constraint Assertion

7.15.3.2 AssertConstraintUsage

Description

An AssertConstraintUsage is a ConstraintUsage that is also an Invariant and, so, is asserted to be true. The asserted ConstraintUsage (which may be the AssertConstraintUsage itself) is related to the AssertConstraintUsage by a Subsetting relationship.

If the AssertConstraintUsage is owned by a Part, then it also subsets the assertedConstraints property of that Part (as defined in the library model for Part), otherwise it subsets constraintChecks, as required for a regular ConstraintUsage.

General Classes

Invariant
ConstraintUsage

Attributes

/assertedConstraint : ConstraintUsage

The ConstraintUsage to be performed by the AssertConstraintUsage. It is the subsettingFeature of the first owned Subsetting Relationship of the AssertConstraintUsage.

Operations

No operations.

Constraints

No constraints.

7.15.3.3 ConstraintDefinition

Description

A ConstraintDefinition is a Definition that is also a Predicate that defines a constraint that may be asserted to hold on a system or part of a system.

A ConstraintDefinition must subclass, directly or indirectly, the base ConstraintDefinition ConstraintCheck from the Systems model library.

General Classes

Definition
Predicate

Attributes

No attributes.

Operations

No operations.

Constraints

No constraints.

7.15.3.4 ConstraintUsage

Description

A ConstraintUsage is a Usage that is also a BooleanExpression, and, so, is typed by a Predicate. Nominally, if the type is a ConstraintDefinition, a ConstraintUsage is a Usage of that ConstraintDefinition. However, other kinds of kernel Predicates are also allowed, to permit use of Predicates from the Kernel Library.

A ConstraintUsage (other than an AssertConstraintUsage owned by a Part) must subset, directly or indirectly, the base ConstraintUsage constraintChecks from the Systems model library.

General Classes

Usage
BooleanExpression

Attributes

/constraintDefinition : Predicate {redefines predicate}

The (single) Predicate is the type of this Constraint Usage. Nominally, this will be ConstraintDefinition, but non-ConstraintDefinition Predicates are also allowed, to permit use of Predicates from the Kernel Library.

Operations

No operations.

Constraints

No constraints.

7.15.4 Constraints Semantics

7.16 Requirements

7.16.1 Requirements Overview

A requirement specifies stakeholder-imposed constraints that a design solution must satisfy to be a valid solution. A RequirementDefinition is a kind of ConstraintDefinition. The requirement definition can contain features that include a combination of text statements (also known as "shall" statements), and more formally specified constraints with constraint expressions. A constraint expressions generally increases the precision of the requirement, and facilitates automated evaluation.

A RequirementUsage is a kind of ConstraintUsage. A requirement usage is a usage of a requirement definition in some context. The context for multiple requirements can be provided by a package, another requirement, or a part. A design solution must satisfy the requirement and all of its member requirements and constraints to be a valid solution.

Like any usage element, the features of the requirement usage can redefine the features of the requirement definition. For example, a requirement definition called MaximumMass may include the constraint {massActual <= massRequired}, and the attributes for massActual and massRequired. The value of the attribute massRequired may not be specified for the requirement definition. The requirement usage called maximumVehicleMass is defined by MaximumMass, and can include the value of the massRequired to be 2000 kilograms. In this way, the requirement definition serves as a requirement template that can be reused and tailored to each context of use.

The top-level requirement can compose a hierarchy of requirement usages, where each nested requirement usage can contain further nested requirement usages. A requirement definition or usage can own zero or more requirement usages, or can contain references to other requirement usages. For a requirement usage to be satisfied, all of its owned and referenced requirements must be satisfied.

A requirement definition and requirement usage have a subject, which if not specified, is the most general thing. A requirement usage can only be satisfied by an entity that is a subset of the subject. For example, if the subject is of type Vehicle, then a standard vehicle model or sports vehicle model can satisfy the requirement, as long as the type of both vehicles is a subclass of the subject Vehicle. The subject type can be restricted to certain kinds of definition elements if it is desired to constrain what kind of entity can satisfy the requirement. For example, the subject type can be restricted to be an action definition, if it is desired to constrain the requirement to be satisfied by action usages. A satisfy relationship between an entity that satisfies a requirement and the requirement must always share a common context with the satisfying entity and the requirement.

Since a requirement is a kind of constraint, a requirement can be evaluated to be true or false. A requirement is satisfied when it is evaluated to be true. A satisfy relationship is established between a requirement usage and the entity that satisfies the requirement. The satisfy relationship must always be contained in a context that also contains the requirement and the entity that is asserted to satisfy it. For the `maximumVehicleMass` requirement above, the `massActual` attribute of the requirement is bound to the mass of the specific vehicle that is asserted to satisfy the requirement. The requirement is satisfied if the required constraint `{mass <= massRequired}` evaluates to true.

A requirement can also contain assumptions, where an assumption is a kind of constraint. For a requirement to be satisfied, all of its assumed constraints must also evaluate to true. For example, the `maximumVehicleMass` requirement may contain an assumption that the vehicle's fuel tank is full of gas, which can be expressed as `{fuelMass == maximumFuelMass}`. This assumed constraint must evaluate to be true for the requirement to be satisfied.

7.16.2 Requirements Concrete Syntax

7.16.2.1 Requirements Textual Notation

7.16.2.1.1 Requirement Definitions

```
RequirementDefinition (m : Membership) : RequirementDefinition =
    DefinitionPrefix(this)? 'requirement' 'def'
    ConstraintDeclaration(this, m) RequirementBody(this)?

RequirementBody (t : Type) =
    ';' | '{' RequirementBodyItem(t)* '}'

RequirementBodyItem (t : Type) =
    DefinitionBodyItem(t)
    | t.ownedFeatureMembership += SubjectMember
    | t.ownedFeatureMembership += RequirementConstraintMember
    | t.ownedFeatureMembership += RequirementVerificationMember

SubjectMember : SubjectMembership =
    DefinitionMemberPrefix(this) ownedSubjectParameter = SubjectUsage(this)

SubjectUsage (m : Membership) : ReferenceUsage =
    Usage(m)

RequirementConstraintMember : RequirementConstraintMembership =
    DefinitionMemberPrefix(this)? RequirementKind(this)
    ownedMemberFeature = RequirementConstraintUsage(this)

RequirementKind (m : RequirementConstraintMembership) : RequirementConstraintKind =
    'assume' { m.kind = 'assumption' }
    | 'require' { m.kind = 'requirement' }

RequirementConstraintUsage (m : Membership) : ConstraintUsage =
    ownedSubsetting += OwnedSubsetting FeatureSpecializationPart(this)?
    CalculationParameterPart(this) RequirementBody(this)
    | 'constraint' CalculationUsageDeclaration(this, m) CalculationBody(this)
```

7.16.2.1.2 Requirement Usages

```
RequirementUsage (m : Membership) : RequirementUsage =
  UsagePrefix(this)? 'requirement'
  CalculationUsageDeclaration(this, m) RequirementBody(this)

RequirementFlowUsage (m : Membership) : RequirementUsage =
  UsagePrefix(this)? 'ref'? 'requirement'
  CalculationUsageDeclaration(this, m) RequirementBody(this)

RequirementRefUsage (m : Membership) : RequirementUsage =
  UsagePrefix(this)? ( 'ref' 'requirement' | isComposite ?= 'requirement' )
  CalculationUsageDeclaration(this, m) RequirementBody(this)

SatisfyRequirementUsage : SatisfyRequirementUsage =
  UsagePrefix(this)? 'satisfy'
  ( ownedSubsetting += OwnedSubsetting | 'requirement' Identification(this, m) )
  FeatureSpecializationPart(this) ( ValuePart(this) | ActionParameterList(this) )
  ( 'by' ownedMembership += SatisfactionConnectorMember(this) )?
  RequirementBody(this)

SatisfactionConnectorMember (s : SatisfyRequirementUsage) : Membership =
  ownedMemberFeature = SatisfactionConnector(s)

SatisfactionConnector (s : SatisfyRequirementUsage ) : BindingConnector =
  ownedFeatureMembership += ConnectorEndMemberFor(s.subjectParameter)
  ownedFeatureMembership += ConnectorEndMember
```

7.16.2.2 Requirements Graphical Notation

7.16.3 Requirements Abstract Syntax

OMG Systems Modeling Language (SysML) v2.0, Submission



Figure 50. Requirement Membership



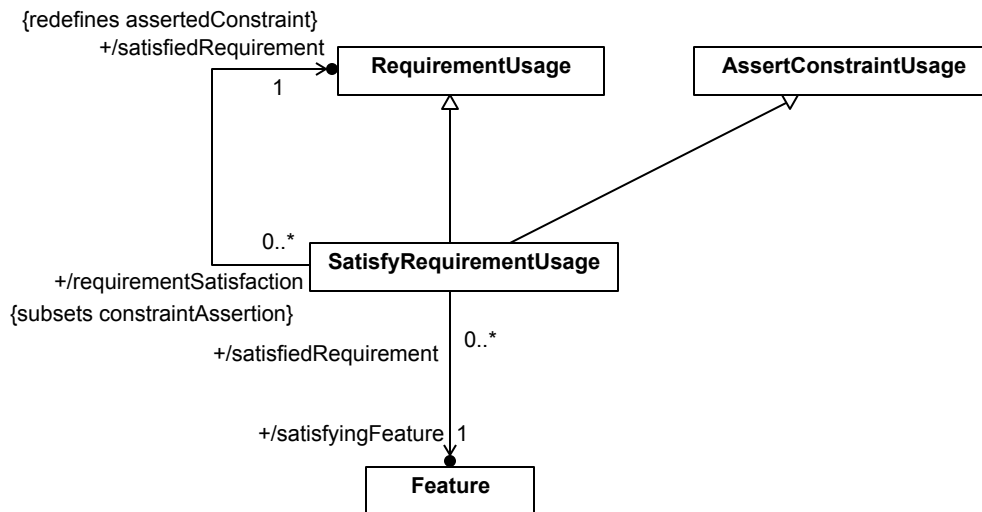


Figure 51. Requirement Satisfaction

7.16.3.2 RequirementConstraintKind

Description

A RequirementConstraintKind indicates whether a ConstraintUsage is an assumption or a requirement in a RequirementDefinition or RequirementUsage.

General Classes

No general classes.

Literal Values

assumption

Indicates that a member ConstraintUsage of a RequirementDefinition or RequirementUsage represents an assumption.

requirement

Indicates that a member ConstraintUsage of a RequirementDefinition or RequirementUsage represents an requirement.

7.16.3.3 RequirementConstraintMembership

Description

A RequirementConstraintMembership is a FeatureMembership for an assumed or required ConstraintUsage of a RequirementDefinition or RequirementUsage. The ownedMemberFeature of a RequirementConstraintMembership must be a ConstraintUsage.

General Classes

FeatureMembership

Attributes

`constraint : ConstraintUsage {redefines ownedMemberFeature}`

The `ConstraintUsage` that is the `ownedMemberFeature` of this `RequirementConstraintUsage`.

`kind : RequirementConstraintKind`

Whether the `RequirementConstraintMembership` is for an assumed or required `ConstraintUsage`.

Operations

No operations.

Constraints

No constraints.

7.16.3.4 RequirementDefinition

Description

A `RequirementDefinition` is a `ConstraintDefinition` that defines a requirement as a constraint that is used in the context of a specification that a valid solution must satisfy.

A `RequirementDefinition` must subclass, directly or indirectly, the base `RequirementDefinition` `RequirementCheck` from the Systems model library.

General Classes

`ConstraintDefinition`

Attributes

`/assumedConstraint : ConstraintUsage [0..*] {subsets ownedFeature}`

The owned `ConstraintUsages` that represent requirements of this `RequirementDefinition`. These are derived as the `ConstraintUsages` related to the `RequirementDefinition` by a `RequirementConstraintMembership` with `kind = requirement`.

`reqId : String [0..1] {redefines humanId}`

An optional modeler-specified identifier for this `RequirementDefinition` (used, e.g., to link it to an original requirement text in some source document), derived as the `modeledId` for the `RequirementDefinition`.

`/requiredConstraint : ConstraintUsage [0..*] {subsets ownedFeature}`

The owned `ConstraintUsages` that represent requirements of this `RequirementDefinition`. These are derived as the `ConstraintUsages` related to the `RequirementDefinition` by a `RequirementConstraintMembership` with `kind = requirement`.

`/subjectParameter : Usage {subsets parameter, ownedFeature}`

The `parameter` of this `RequirementDefinition` that is owned via a `SubjectMembership`, which must redefine, directly or indirectly, the `subject` parameter of the base `RequirementDefinition` `RequirementCheck` from the Systems model library.

`/text : String [0..*]`

An optional textual statement of the requirement represented by this `RequirementDefinition`, derived as the `bodies` of the `documentaryComments` of the `RequirementDefinition`.

Operations

No operations.

Constraints

No constraints.

7.16.3.5 RequirementUsage

Description

A `RequirementUsage` is a `Usage` of a `RequirementDefinition`.

A `RequirementUsage` (other than a `SatisfyRequirementUsage` owned by a `Part`) must subset, directly or indirectly, the base `RequirementUsage` `requirementChecks` from the Systems model library.

General Classes

`ConstraintUsage`

Attributes

`/assumedConstraint : ConstraintUsage [0..*] {subsets ownedFeature}`

The owned `ConstraintUsages` that represent assumptions of this `RequirementUsage`. These are derived as the `ConstraintUsages` related to the `RequirementUsage` by a `RequirementConstraintMembership` with `kind = assumption`.

`reqId : String [0..1] {redefines humanId}`

An optional modeler-specified identifier for this `RequirementUsage` (used, e.g., to link it to an original requirement text in some source document), derived as the `modeledId` for the `RequirementUsage`.

`/requiredConstraint : ConstraintUsage [0..*] {subsets ownedFeature}`

The owned `ConstraintUsages` that represent requirements of this `RequirementUsage`. These are derived as the `ConstraintUsages` related to the `RequirementUsage` by a `RequirementConstraintMembership` with `kind = requirement`.

`/requirementDefinition : RequirementDefinition {redefines constraintDefinition}`

The `RequirementDefinition` that is the single type of this `RequirementUsage`.

`/subjectParameter : Usage {subsets parameter, ownedFeature}`

The `parameter` of this `RequirementUsage` that is owned via a `SubjectMembership`, which must redefine, directly or indirectly, the `subject` parameter of the base `RequirementDefinition RequirementCheck` from the `Systems` model library.

`/text : String [0..*]`

An optional textual statement of the requirement represented by this `RequirementUsage`, derived as the `bodies` of the `documentaryComments` of the `RequirementDefinition`.

Operations

No operations.

Constraints

No constraints.

7.16.3.6 SatisfyRequirementUsage

Description

A `SatisfyRequirementUsage` is an `AssertConstraintUsage` that asserts that a satisfied `RequirementUsage` is true for a specific `satisfyingSubject`. The satisfied `RequirementUsage` is related to the `SatisfyRequirementUsage` by a `Subsetting` relationship.

General Classes

`AssertConstraintUsage`
`RequirementUsage`

Attributes

`/satisfiedRequirement : RequirementUsage {redefines assertedConstraint}`

The `RequirementUsage` that is satisfied by the `satisfyingSubject` of this `SatisfyRequirementUsage`. It is the `subsettedFeature` of the first owned `Subsetting Relationship` of the `SatisfyRequirementUsage`.

`/satisfyingFeature : Feature`

The `Feature` that represents the actual subject that is asserted to satisfy the `satisfiedRequirement`. The `satisfyingFeature` must be the target of a `BindingConnector` from the `subjectParameter` of the `satisfiedRequirement`.

Operations

No operations.

Constraints

No constraints.

7.16.3.7 SubjectMembership

Description

A `SubjectMembership` is a `ParameterMembership` that indicates that its `ownedSubjectParameter` is the subject Parameter for its `owningType`. The `owningType` of a `SubjectMembership` must be a `CaseDefinition`, `CaseUsage`, `RequirementDefinition` or `RequirementUsage`.

General Classes

`ParameterMembership`

Attributes

`ownedSubjectParameter` : `Usage` {redefines `ownedMemberParameter`}

The `Usage` that is the `ownedMemberParameter` of this `SubjectMembership`.

Operations

No operations.

Constraints

No constraints.

7.16.4 Requirements Semantics

7.17 Cases

7.17.1 Cases Overview

A case is a general concept that provides the basis for more specific cases including an analysis case and a verification case. A `CaseDefinition` is a specialized kind of `CalculationDefinition` with a specified objective, that is a `RequirementUsage`. The objective is used to specify what the case is intended to achieve regarding the subject, which generally includes some combination of collecting information about the subject and evaluating the subject.. The subject is an input to the case, and the return result is the designated output of the case. A case definition can contain a series of actions needed to achieve the case objective. A `CaseUsage` is a usage of a case definition.

7.17.2 Cases Concrete Syntax

7.17.2.1 Cases Textual Notation

7.17.2.1.1 Case Definitions

```
CaseDefinition (m : Membership) : CaseDefinition =
    DefinitionPrefix(this)? 'case' 'def'
    CalculationDeclaration(this, m) CaseBody(this)

CaseBody (t : Type) =
    ';'
    | '{' CaseBodyItem(t)*
      ( t.ownedFeatureMembership += ResultExpressionMember )?
    '}'

CaseBodyItem (t : Type) =
    ActionBodyItem(t)
    | t.ownedFeatureMembership += SubjectMember
    | t.ownedFeatureMembership += ObjectiveMember

ObjectiveMember : ObjectiveMembership =
    DefinitionMemberPrefix(this) 'objective'
    ownedObjectiveRequirement = ObjectiveRequirementUsage(this)

ObjectiveRequirementUsage (m : Membership) : RequirementUsage =
    CalculationUsageDeclaration(this, m) RequirementBody(this)
```

7.17.2.1.2 Case Usages

```
CaseUsage (m : Membership) : CaseUsage =
    UsagePrefix(this)? 'case'
    CalculationUsageDeclaration(this, m) CaseBody(this)

CaseFlowUsage (m : Membership) : CaseUsage =
    UsagePrefix(this)? 'ref'? 'case'
    CalculationUsageDeclaration(this, m) CaseBody(this)

CaseRefUsage (m : Membership) : CaseUsage =
    UsagePrefix(this)? ( 'ref' 'case' | isComposite ?= 'case' )
    CalculationUsageDeclaration(this ,m) CaseBody(this)
```

7.17.2.2 Cases Graphical Notation

7.17.3 Cases Abstract Syntax

7.17.3.1 Overview

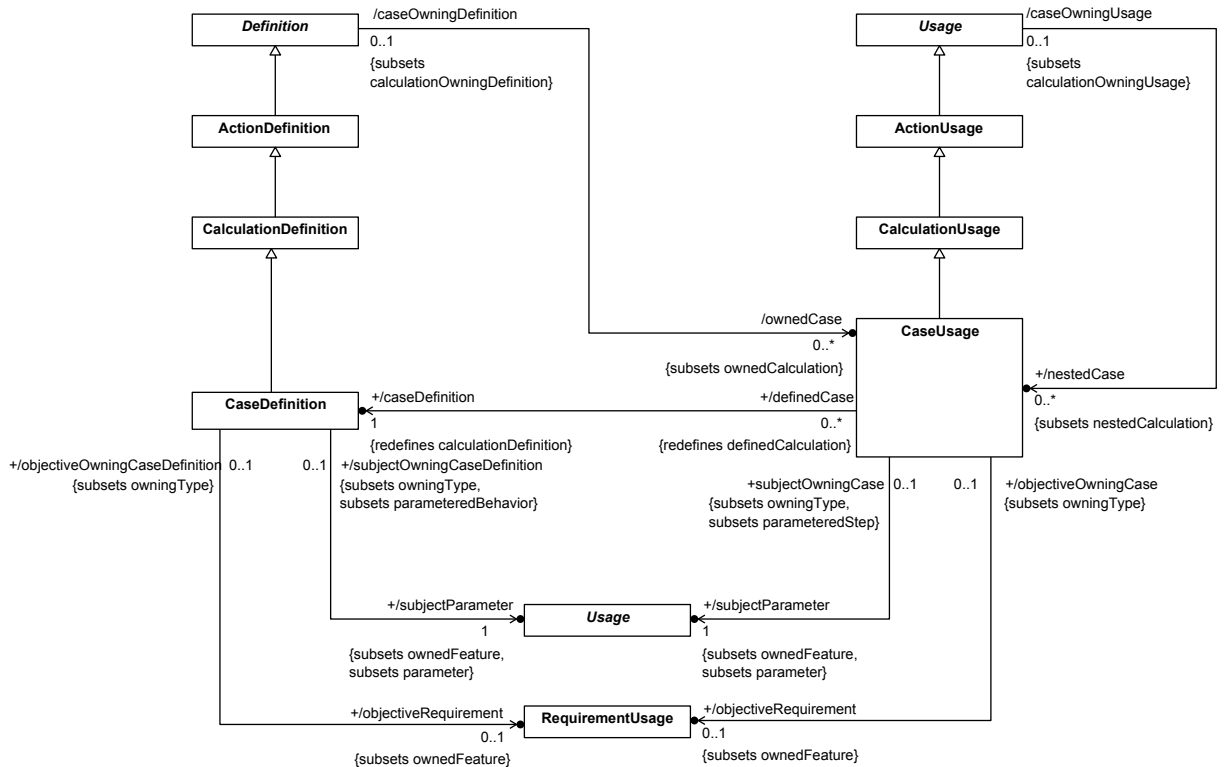


Figure 52. Case Definition and Usage

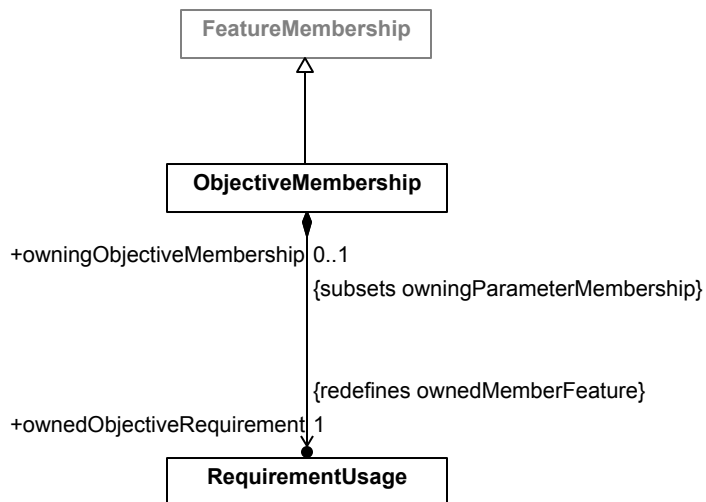


Figure 53. Case Membership

7.17.3.2 CaseDefinition

Description

A CaseDefinition is a CalculationDefinition for a process, often involving collecting evidence or data, relative to a subject, producing a result that meets an objective.

A CaseDefinition must subclass, directly or indirectly, the base CaseDefinition Case from the Systems model library.

General Classes

CalculationDefinition

Attributes

/objectiveRequirement : RequirementUsage [0..1] {subsets ownedFeature}

The

ownedFeature

of this CaseDefinition that is owned via an ObjectiveMembership, and that must redefine, directly or indirectly, the `objectiveRequirementUsage` of the base CaseDefinition Case from the Systems model library.

/subjectParameter : Usage {subsets parameter, ownedFeature}

The `parameter` of this CaseDefinition that is owned via a SubjectMembership, which must redefine, directly or indirectly, the `subject` parameter of the base CaseDefinition Case from the Systems model library.

Operations

No operations.

Constraints

No constraints.

7.17.3.3 CaseUsage

Description

A CaseUsage is a Usage of a CaseDefinition.

A CaseUsage must subset, directly or indirectly, either the base CaseUsage `cases` from the Systems model library, if it is not owned by a CaseDefinition or CaseUsage, or the CaseUsage `subcases` inherited from its owner, otherwise.

General Classes

CalculationUsage

Attributes

/caseDefinition : CaseDefinition {redefines calculationDefinition}

The CaseDefinition that is the type of this CaseUsage.

/objectiveRequirement : RequirementUsage [0..1] {subsets ownedFeature}

The

ownedFeature

of this CaseUsage that is owned via an ObjectiveMembership, and that must redefine, directly or indirectly, the `objective` RequirementUsage of the base CaseDefinition Case from the Systems model library.

/subjectParameter : Usage {subsets parameter, ownedFeature}

The `parameter` of this CaseUsage that is owned via a SubjectMembership, which must redefine, directly or indirectly, the `subject` parameter of the base CaseDefinition Case from the Systems model library.

Operations

No operations.

Constraints

No constraints.

7.17.3.4 ObjectiveMembership

Description

An ObjectiveMembership is a FeatureMembership that indicates that its `ownedObjectiveRequirement` is the objective RequirementUsage for its `owningType`. The `owningType` of an ObjectiveMembership must be a CaseDefinition or CaseUsage.

General Classes

FeatureMembership

Attributes

`ownedObjectiveRequirement` : RequirementUsage {redefines ownedMemberFeature}

The RequirementUsage that is the

`ownedMemberFeature`

of this RequirementUsage.

Operations

No operations.

Constraints

No constraints.

7.17.4 Cases Semantics

7.18 Analysis Cases

7.18.1 Analysis Cases Overview

An analysis can be specified in SysML and solved by external solvers. The analysis specification may include a combination of equations to be solved, a set of input and output parameters that are used in the equations, initial conditions, and boundary conditions.

An `AnalysisCaseDefinition` is a kind of `CaseDefinition` that enables the specification of an analysis. An `AnalysisCaseUsage` is a kind of `CaseUsage`. An analysis case usage is a usage of an analysis case definition. The analysis case definition and analysis case usage may have an analysis objective to specify what the analysis is intended to achieve. The analysis objective can be defined in terms of one or more questions to be answered. The subject of the analysis identifies what is being analyzed, and is an input to the analysis case.

The subject of the analysis is typically quite general for the analysis case definition, and then made more specific for the analysis case usage. Executing the analysis case usage returns an analysis result about the subject. For example, a fuel economy analysis of a vehicle subject returns the estimated fuel economy of the vehicle, given a set of analysis inputs and assumed conditions. The analysis result can be evaluated to determine whether it satisfies the analysis objective.

The analysis case can include a set of analysis actions, each of which can specify calculations that return results. As an example, the fuel economy analysis referred to above may require both a dynamics analysis and a fuel consumption analysis. The dynamics analysis determines the vehicle trajectory and the required engine power versus time. The fuel consumption analysis determines the fuel consumed to achieve the required engine power. Both the dynamics analysis and the fuel consumption analysis may require multiple calculations.

As noted above, an analysis case is a specification of an analysis that is often performed by solvers external to the SysML modeling tool. The analysis case does not specify how the analysis is executed. For example, the analysis does not specify the type of integration algorithm that is used to solve a differential equation.

An analysis case can also specify a set of simultaneous equations to be solved. This is done defining one or more constraint expressions that logically AND each of the equations, and asserting that the constraint must be true. A solver would be expected to solve the equations such that it returns values that satisfy each equation.

A trade-off analysis is a special kind of analysis used to evaluate and compare alternatives. Each alternative being evaluated is a subject of the trade-off analysis. The trade-off analysis also includes a set of criteria that are evaluated for each alternative, and an objective function that provides an overall evaluation result for each alternative. An example of a trade-off analysis is an analysis that evaluates and compares multiple vehicle design alternatives in terms of their maximum acceleration, reliability, and fuel economy (i.e., criterion). The objective function establishes a relative weighting of each criterion based on its importance to the stakeholder. The evaluation result is computed for each alternative based on a weighted sum of the normalized value for maximum acceleration, reliability, and fuel economy. The evaluation results for each alternative are then compared to determine a preferred solution.

Submission Note. Support for trade-off analysis will be provided in the revised submission.

7.18.2 Analysis Cases Concrete Syntax

7.18.2.1 Analysis Cases Textual Notation

```

AnalysisCaseDefinition (m : Membership) : AnalysisCaseDefinition =
  DefinitionPrefix(this)? 'analysis' 'def'
  CalculationDeclaration(this, m) CaseBody(this)

AnalysisCaseUsage (m : Membership) : CaseUsage =
  UsagePrefix(this)? 'analysis'
  CalculationUsageDeclaration(this, m) CaseBody(this)

AnalysisCaseFlowUsage (m : Membership) : CaseUsage =
  UsagePrefix(this)? 'ref'? 'analysis'
  CalculationUsageDeclaration(this, m) CaseBody(this)

AnalysisCaseRefUsage (m : Membership) : AnalysisCaseUsage =
  UsagePrefix(this)? ( 'ref' 'analysis' | isComposite ?= 'analysis' )
  CalculationUsageDeclaration(this ,m) CaseBody(this)

```

Submission Note. Additional concrete syntax for specialized analysis actions is planned for the revised submission.

7.18.2.2 Analysis Cases Graphical Notation

7.18.3 Analysis Cases Abstract Syntax

7.18.3.1 Overview

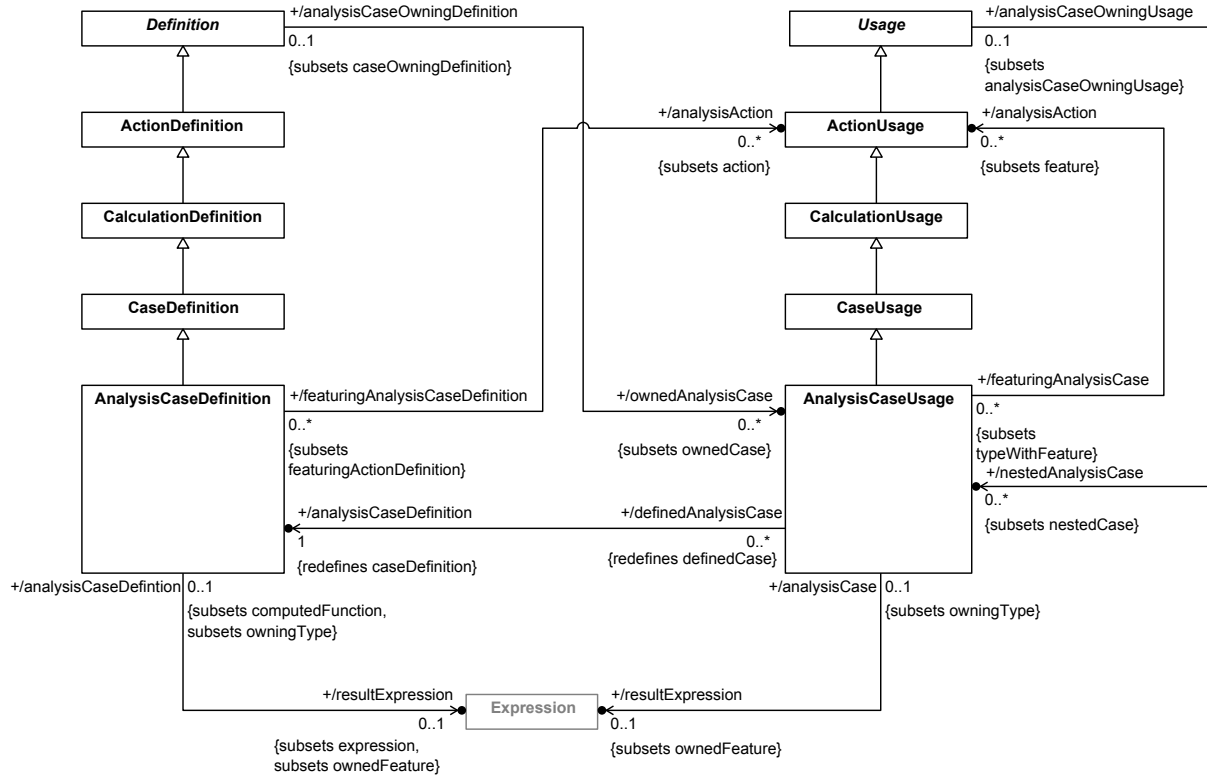


Figure 54. Analysis Case Definition and Usage

Submission Note. Additional abstract syntax for specialize analysis actions is planned for the revised submission.

7.18.3.2 AnalysisCaseDefinition

Description

An AnalysisCaseDefinition is a CaseDefinition for the case of carrying out an analysis.

An AnalysisCaseDefinition must subclass, directly or indirectly, the base AnalysisCaseDefinition AnalysisCase from the Systems model library.

General Classes

CaseDefinition

Attributes

/analysisAction : ActionUsage [0..*] {subsets action}

The `actions` of the AnalysisCaseDefinitions that are typed as AnalysisActions. Each `analysisAction` ActionUsage must subset the `analysisSteps` ActionUsage of the base AnalysisCaseDefinition AnalysisCase from the Systems model library.

/resultExpression : Expression [0..1] {subsets expression, ownedFeature}

The Expression used to compute the `result` of the AnalysisCaseDefinition, derived as the Expression own via a ResultExpressionMembership. The `resultExpression` must redefine directly or indirectly, the `resultEvaluation` Expression of the base AnalysisCaseDefinition AnalysisCase from the Systems model library.

Operations

No operations.

Constraints

No constraints.

7.18.3.3 AnalysisCaseUsage

Description

An AnalysisCaseUsage is a Usage of an AnalysisCaseDefinition.

An AnalysisCaseUsage must subset, directly or indirectly, either the base AnalysisCaseUsage `analysisCases` from the Systems model library, if it is not owned by an AnalysisCaseDefinition or AnalysisCaseUsage, or the AnalysisCaseUsage `subAnalysisCases` inherited from its owner, otherwise.

General Classes

CaseUsage

Attributes

/analysisAction : ActionUsage [0..*] {subsets feature}

The features of the AnalysisCaseUsage that are typed as AnalysisActions. Each analysisAction ActionUsage must subset the analysisSteps ActionUsage of the base AnalysisCaseDefinition AnalysisCase from the Systems model library.

/analysisCaseDefinition : AnalysisCaseDefinition {redefines caseDefinition}

The AnalysisCaseDefinition that is the type of this AnalysisCaseUsage.

/resultExpression : Expression [0..1] {subsets ownedFeature}

The Expression used to compute the result of the AnalysisCaseUsage, derived as the Expression own via a ResultExpressionMembership. The resultExpression> must redefine directly or indirectly, the resultEvaluation Expression of the base AnalysisCaseDefinition AnalysisCase from the Systems model library.

Operations

No operations.

Constraints

No constraints.

7.18.4 Analysis Cases Semantics

7.19 Verification Cases

7.19.1 Verification Cases Overview

Verification cases are used to specify the actions needed to verify that a system or component satisfies its requirements. The verification cases are an important input to verification planning and execution.

A VerificationCaseDefinition is a kind of CaseDefinition. A verification case definition defines a set of verification actions that are needed to verify that a system or other entity satisfies its requirements. A VerificationCaseUsage is a kind of Caseusage. A verification case usage is a usage of a verification case definition.

The verification case has a verification objective and a subject. The subject is the system or other entity that is being evaluated as to whether it satisfies the requirements. The subject is often referred to as the unit under test or unit under verification, and is an input to the verification case. The subject of the verification case usage can subset the subject of the verification case definition to make it more specific. The verification objective can be stated in terms of a satisfying a set of requirements, such as the objective to evaluate whether the system satisfies its environmental requirements.

A typical verification case includes a set of verification actions to collect the data, analyze the data, and then evaluate whether the resulting analysis result satisfies the requirement.

- The first step is to collect the data about the subject needed to support the verification objective, which is typically done using verification methods such as analysis, inspection, demonstration, and test.
- The second step involves an analysis of this collected data. For example, the data may include multiple measurements that span a range of conditions for a particular individual, or measurements of different individuals. This analysis step may need to determine the probability distribution, mean, and standard deviation associated with the measurements.
- The third step is to evaluate whether the results from the data analysis satisfy the requirement or requirements.

Each of the verification actions in the verification case requires a set of resources to perform the actions. This may include verification personnel, test equipment, facilities, and other resources. These resources may be represented in the model as parts that perform actions, or other inputs and outputs of actions.

A verification case can be used to verify that one or more requirements are satisfied. A verify relationship is defined between the verification case and each requirement it is intended to verify (to be included). Executing the verification case will return a verification result, such as pass, fail, or inconclusive.

7.19.2 Verification Cases Concrete Syntax

7.19.2.1 Verification Cases Textual Notation

```
VerificationCaseDefinition (m : Membership) : VerificationCaseDefinition =  
    DefinitionPrefix(this)? 'verification' 'def'  
    CalculationDeclaration(this, m) CaseBody(this)  
  
VerificationCaseFlowUsage (m : Membership) : VerificationCaseUsage =  
    UsagePrefix(this)? 'verification'  
    CalculationUsageDeclaration(this, m) CaseBody(this)  
  
VerificationCaseUsage (m : Membership) : VerificationCaseUsage =  
    UsagePrefix(this)? 'ref'? 'verification'  
    CalculationUsageDeclaration(this, m) CaseBody(this)  
  
VerificationCaseRefUsage (m : Membership) : AnalysisCaseUsage =  
    UsagePrefix(this)? ( 'ref' 'verification' | isComposite ?= 'verification' )  
    CalculationUsageDeclaration(this, m) CaseBody(this)  
  
RequirementVerificationMember : RequirementVerificationMembership =  
    DefinitionMemberPrefix kind = RequirementVerificationKind  
    ownedRequirement = RequirementVerificationUsage  
  
RequirementVerificationKind : RequirementConstraintKind =  
    'verify' { m.kind = 'requirement' }  
  
RequirementVerificationUsage : RequirementUsage =  
    ownedRelationship += OwnedSubsetting FeatureSpecialization(this)*  
    CalculationUsageParameterPart(this)? RequirementBody(this)  
    | 'requirement' CalculationUsageDeclaration(this) RequirementBody(this)
```

7.19.2.2 Verification Cases Graphical Notation

7.19.3 Verification Cases Abstract Syntax

7.19.3.1 Overview

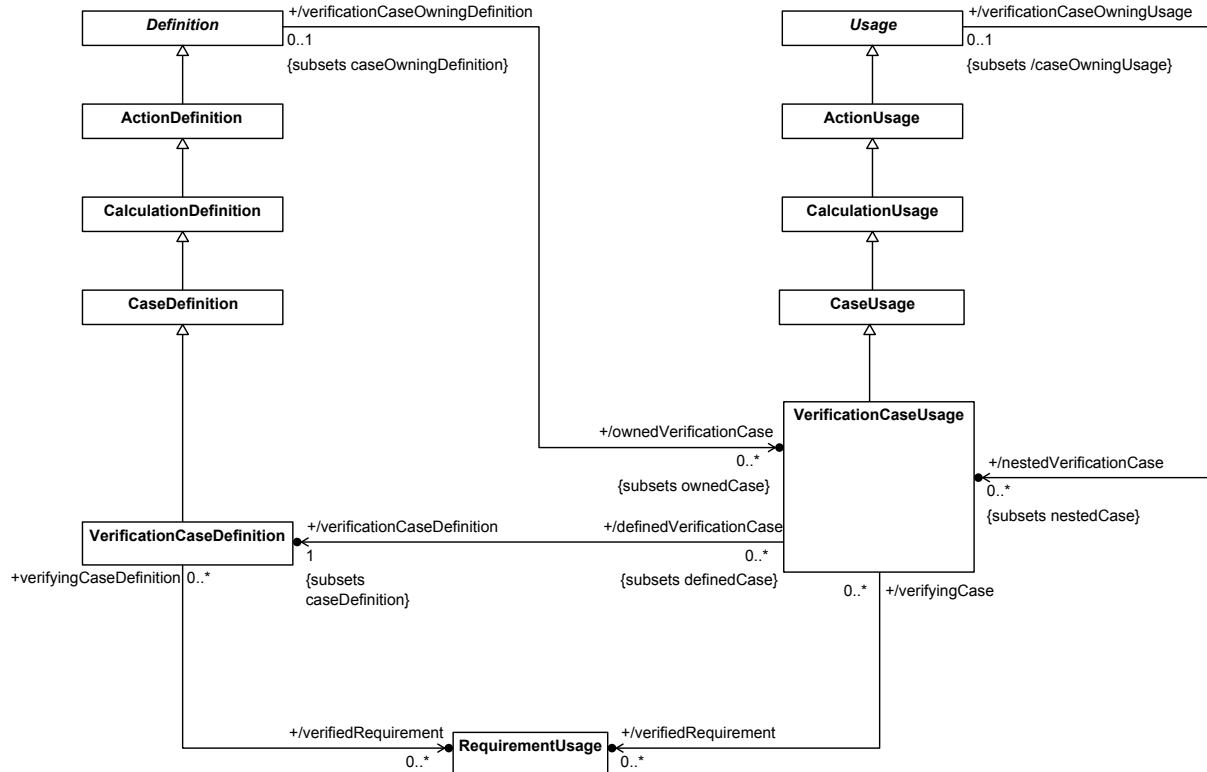


Figure 55. Verification Case Definition and Usage

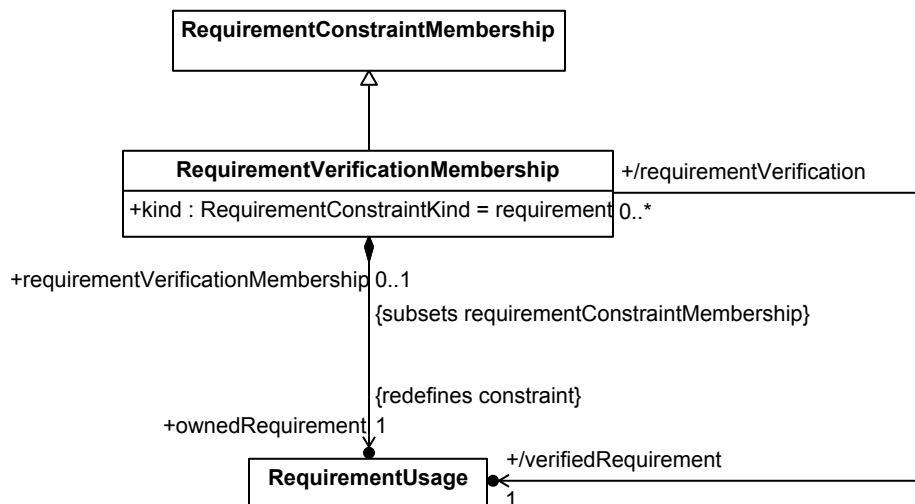


Figure 56. Verification Membership

7.19.3.2 RequirementVerificationMembership

Description

A **RequirementVerificationMembership** is a **RequirementConstraintMembership** used in the objective of a **VerificationCase** to identify a **Requirement** that is verified by the **VerificationCase**.

General Classes

RequirementConstraintMembership

Attributes

kind : RequirementConstraintKind

The kind of a RequirementVerificationMembership must be requirement.

ownedRequirement : RequirementUsage {redefines constraint}

The owned Requirement that acts as the constraint for this RequirementVerificationMembership. This will either be the verifiedRequirement, or it will subset the verifiedRequirement.

/verifiedRequirement : RequirementUsage

The RequirementUsage that is identified as being verified. This is derived as being the first RequirementUsage subset by the owningRequirement, if there is one, and, otherwise, the owningRequirement itself.

Operations

No operations.

Constraints

No constraints.

7.19.3.3 VerificationCaseDefinition

Description

A VerificationCaseDefinition is a CaseDefinition for the purpose of verification of the subject of the case against its requirements.

A VerificationCaseDefinition must subclass, directly or indirectly, the base VerificationCaseDefinition VerificationCase from the Systems model library.

General Classes

CaseDefinition

Attributes

/verifiedRequirement : RequirementUsage [0..*]

The RequirementUsages verified by this VerificationCaseDefinition, derived as the verifiedRequirements of all RequirementVerificationMemberships of the objectiveRequirement.

Operations

No operations.

Constraints

No constraints.

7.19.3.4 VerificationCaseUsage

Description

A VerificationCaseUsage is a Usage of a VerificationCaseDefinition.

A VerificationCaseUsage must subset, directly or indirectly, either the base VerificationCaseUsage `verificationCases` from the Systems model library, if it is not owned by a VerificationCaseDefinition or VerificationCaseUsage, or the VerificationCaseUsage `subVerificationCases` inherited from its owner, otherwise.

General Classes

CaseUsage

Attributes

`/verificationCaseDefinition : VerificationCaseDefinition {subsets caseDefinition}`

The VerificationCase that defines this VerificationCaseUsage.

`/verifiedRequirement : RequirementUsage [0..*]`

The RequirementUsages verified by this VerificationCaseUsage, derived as the `verifiedRequirements` of all RequirementVerificationMemberships of the `objectiveRequirement`.

Operations

No operations.

Constraints

No constraints.

7.19.4 Verification Cases Semantics

7.20 Views

7.20.1 Views Overview

A view is intended to provide information that addresses some aspect of a system or domain of interest that one or more stakeholders care about. This information can be extracted from the model and rendered in some form, such as a diagram, table, or a document that contains diagrams, tables, and text.

SysML includes a set of standard views that are commonly used to describe systems. The standard views include textual, graphical, and tabular renderings of model information. In addition to the standard views, user defined views.

A Viewpoint is a specialized kind of Definition element that specifies the information about a system or domain that is of interest to one or more stakeholders. A ViewDefinition is a specialized kind of Definition element that specifies how to create a view artifact to satisfy one or more viewpoints. A ViewpointUsage and ViewUsage are specialized kinds of Usage elements.

A view definition can include a query expression to extract the relevant model content, and a rendering specification that specifies how the model content should be rendered in a view artifact. A view usage is a usage of a view definition that can expose a portion of the model to limit the scope of the query. Executing the query expression returns the model elements that meet the query criteria. The query results can be referenced by a query package and persisted in the model. View usages can be nested and ordered within a composite view to generate composite view artifacts. The view definition and view usage also can contain a rendering specification to specify the symbolic representation, style, and layout for a particular view.

Complex view definitions with deeply nested structures can be rendered as documents, where each nested view usage corresponds to a section of a document, and the ordering represents the order of the section within the document. Within each section of the document, the nested view usages can specify the information that is rendered as a combination of text, graphical, and tabular information.

7.20.2 Views Concrete Syntax

Release Note. This is a preliminary concrete syntax model for views and viewpoints. More complete syntax will be provided in future releases as the abstract syntax is updated.

7.20.2.1 Views Textual Notation

7.20.2.1.1 Views

```
ViewDefinition (m : Membership) : ViewDefinition =
    DefinitionPrefix(this)? 'view' 'def' DefinitionDeclaration(this, m)
    DefinitionBody(this)

ViewUsage (m : Membership) : ViewUsage =
    UsagePrefix(this)? 'view' UsageDeclaration(this, m)?
    ValueOrFlowPart(this)? ViewBody(this)

ViewFlowUsage (m : Membership) : ViewUsage =
    UsagePrefix(this)? 'ref'? 'view' UsageDeclaration(this, m)?
    ValueOrFlowPart(this)? ViewBody(this)

ViewRefUsage (m : Membership) : ViewUsage =
    UsagePrefix(this)? ( 'ref' 'view' | isComposite ?= 'view' )
    UsageDeclaration(this, m)? ValueOrFlowPart(this)? ViewBody(this)

ViewBody (v : ViewUsage) =
    ';' | '{' ViewBodyItem(v) * '}'

ViewBodyItem (v : ViewUsage) =
    DefinitionBodyItem(v)
    | v.ownedImport += Expose

Expose : Expose =
    ( ownedRelationship += PrefixDocumentation ) *
    ( visibility = BasicVisibilityIndicator )?
    'expose' importedPackage = [Qualified Name] ';'

```

7.20.2.1.2 Viewpoints

```
ViewpointDefinition (m : Membership) : ViewpointDefinition =
  DefinitionPrefix(this)? 'viewpoint' 'def' ConstraintDeclaration(this, m)
  RequirementBody(this)

ViewpointUsage (m : Membership) : ViewpointUsage =
  UsagePrefix(this)? 'viewpoint' CalculationUsageDeclaration(this, m)
  RequirementBody

ViewpointFlowUsage (m : Membership) : ViewpointUsage =
  UsagePrefix(this)? 'ref'? 'viewpoint' CalculationUsageDeclaration(this, m)
  RequirementBody(this)

ViewpointRefUsage (m : Membership) : ViewpointUsage =
  UsagePrefix(this)? ( 'ref' 'viewpoint' | isComposite ?= 'viewpoint' )
  CalculationUsageDeclaration(this, m) RequirementBody(this)
```

7.20.2.1.3 Renderings

```
RenderingDefinition (m : Membership) : RenderingDefinition =
  DefinitionPrefix(this)? 'rendering' 'def' Definition(this, m)

RenderingUsage (m : Membership) : RenderingUsage =
  UsagePrefix(this)? 'rendering' Usage(this, m)

RenderingFlowUsage (m : Membership) : RenderingUsage =
  UsagePrefix(this)? 'ref' 'rendering' Usage(this. m)

RenderingRefUsage (m : Membership) : RenderingUsage =
  UsagePrefix(this)? ( 'ref' 'rendering' | isComposite ?= 'rendering' )
  Usage(this, m)
```

7.20.2.2 Views Graphical Notation

7.20.3 Views Abstract Syntax

7.20.3.1 Overview

Submission Note. This is a preliminary abstract syntax model for views and viewpoints. A complete model will be provided in the revised submission.

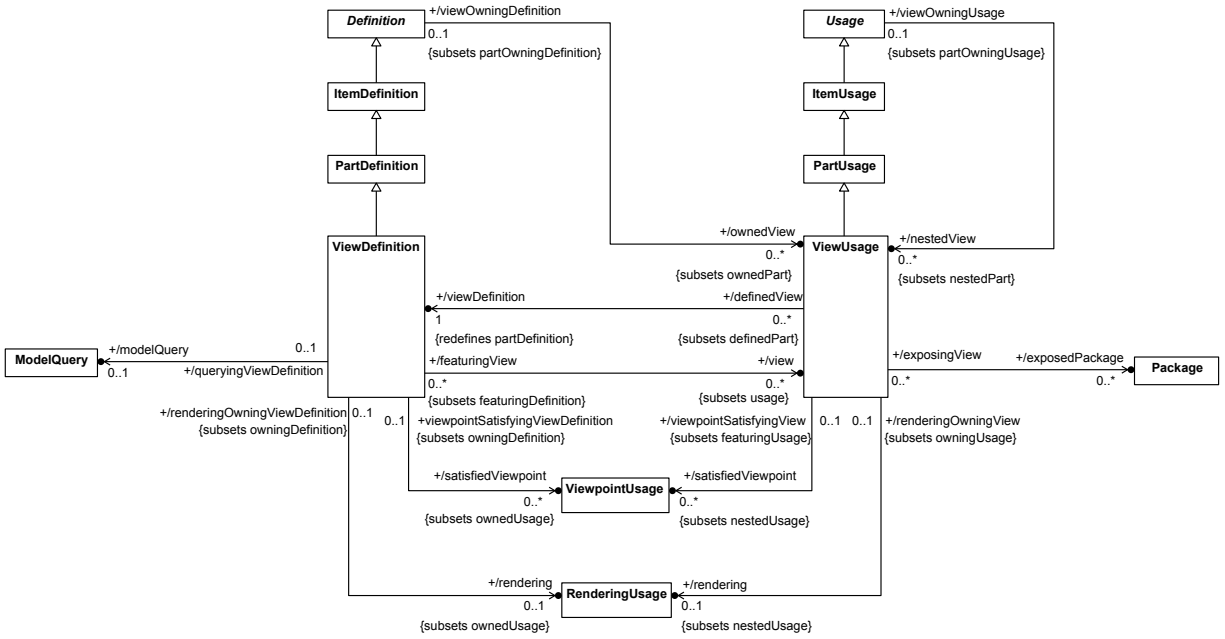


Figure 57. View Definition and Usage

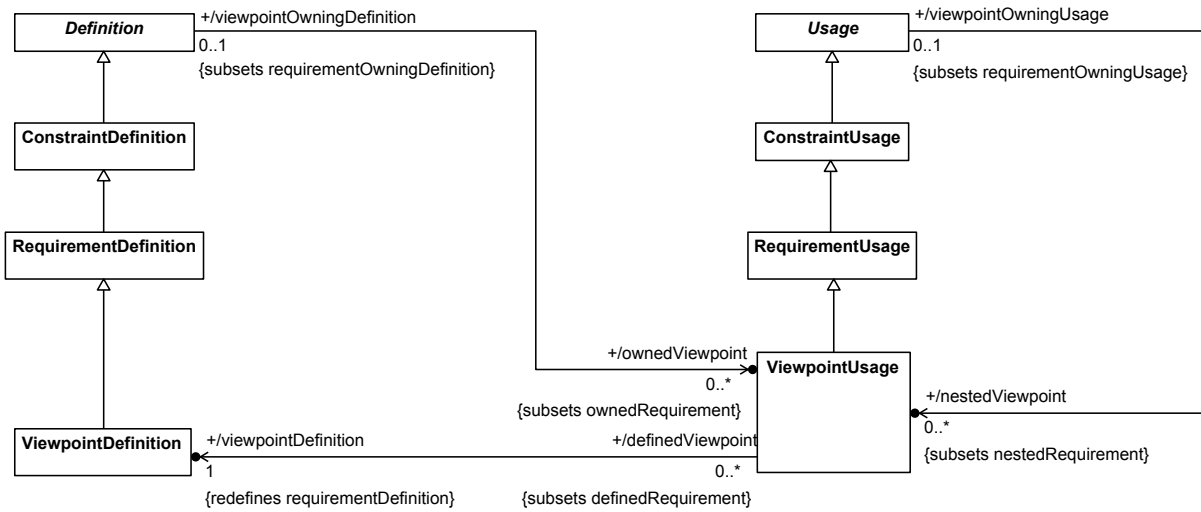


Figure 58. Viewpoint Definition and Usage

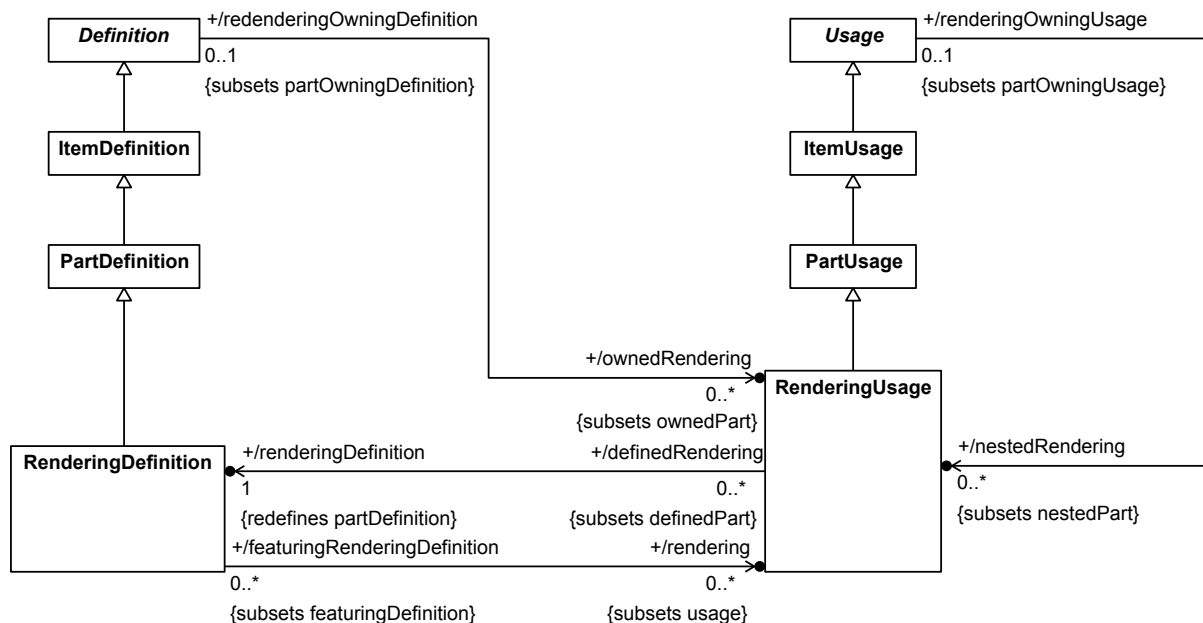


Figure 59. Rendering Definition and Usage

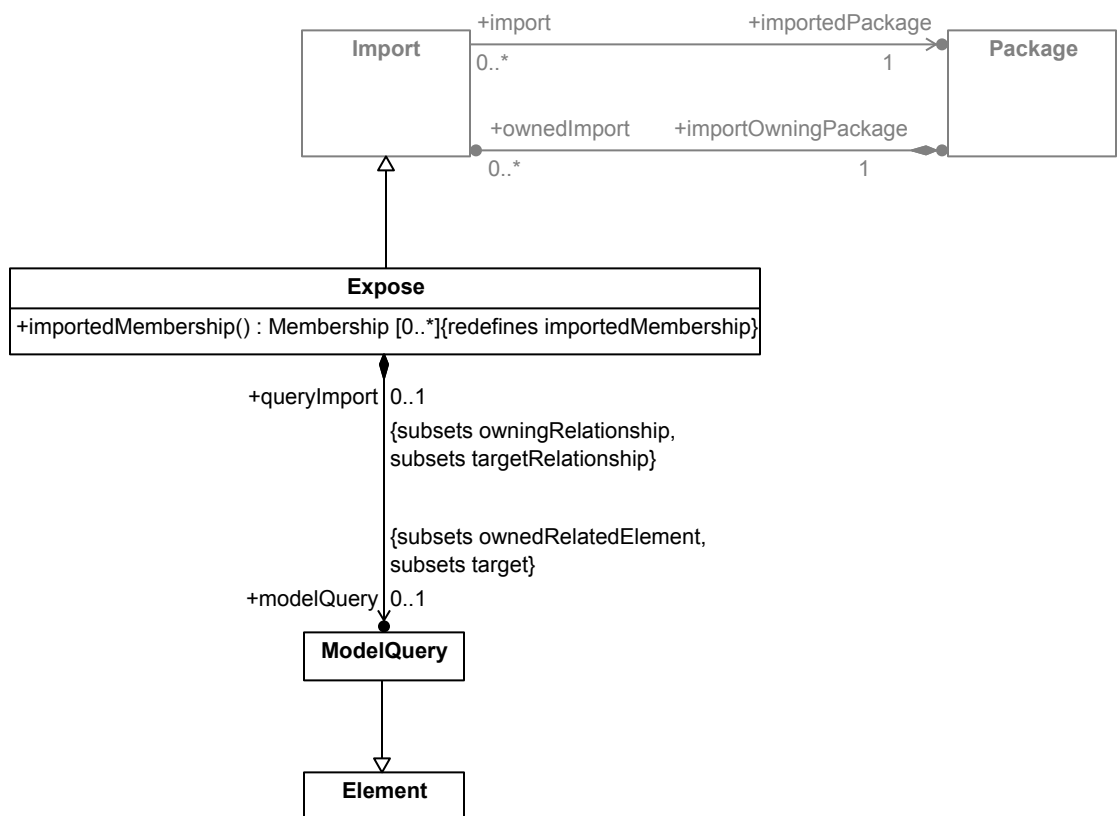


Figure 60. Expose Relationship

7.20.3.2 Expose

Description

An Expose is an Import of a Package into a ViewUsage that provides the root for determining what Elements are to be included in a view. It may optionally include a `modelQuery` to selectively gather the Elements to included.

General Classes

Import

Attributes

`modelQuery` : `ModelQuery` [0..1] {subsets `ownedRelatedElement`, `target`}

A static query to be run on the `importedPackage` to determine which Memberships are actually imported.

Operations

`importedMembership()` : `Membership` [0..*]

Return the public Memberships included from the `importedPackage` that meet the `modelQuery` (if one is given).

Constraints

No constraints.

7.20.3.3 ModelQuery

Description

A `ModelQuery` specifies a query that can be run statically against a specific Package in order to filter which Memberships are imported from that Package.

General Classes

Element

Attributes

No attributes.

Operations

No operations.

Constraints

No constraints.

7.20.3.4 RenderingDefinition

Description

A `RenderingDefinition` is a `PartDefinition` that defines a specific rendering of the content of a model view (e.g., symbols, style, layout, etc.).

A `RenderingDefinition` must subclass, directly or indirectly, the base `RenderingDefinition` `Rendering` from the Systems model library.

General Classes

`PartDefinition`

Attributes

`/rendering : RenderingUsage [0..*] {subsets usage}`

The `usages` of a `RenderingDefinition` that are `RenderingUsages`.

Operations

No operations.

Constraints

No constraints.

7.20.3.5 RenderingUsage

Description

A `RenderingUsage` is the usage of a `RenderingDefinition` to specify the rendering of a specific model view to produce a physical view artifact.

A `RenderingUsage` must subset, directly or indirectly, the base `RenderingUsage` `renderings` from the Systems model library.

General Classes

`PartUsage`

Attributes

`/renderingDefinition : RenderingDefinition {redefines partDefinition}`

The `RenderingDefinition` that defines this `RenderingUsage`.

Operations

No operations.

Constraints

No constraints.

7.20.3.6 ViewDefinition

Description

A `ViewDefinition` is a `PartDefinition` that specifies how a view artifact is constructed to satisfy a `viewpoint`. It specifies a `modelQuery` to define the model content to be presented and a `rendering` to define how the model content is presented.

A `ViewDefinition` must subclass, directly or indirectly, the base `ViewDefinition` `View` from the Systems model library.

General Classes

`PartDefinition`

Attributes

`/modelQuery : ModelQuery [0..1]`

A static query to be run against the `exposedPackage` of a `ViewUsage` of this `ViewDefinition` in order to determine the model elements to be included in a view, derived as the single `ModelQuery` that is a member of the `ViewDefinition`.

`/rendering : RenderingUsage [0..1] {subsets ownedUsage}`

The `RenderingUsage` to be used to render views defined by this `ViewDefinition`.

`/satisfiedViewpoint : ViewpointUsage [0..*] {subsets ownedUsage}`

The `ownedUsages` of this `ViewDefinition` that are `ViewpointUsages` for viewpoints satisfied by the `ViewDefinition`.

`/view : ViewUsage [0..*] {subsets usage}`

The `usages` of this `ViewDefinition` that are `ViewUsages`.

Operations

No operations.

Constraints

No constraints.

7.20.3.7 ViewpointDefinition

Description

A `ViewpointDefinition` is a `RequirementDefinition` that specifies one or more stakeholder concerns that to be satisfied by created a view of a model.

A `ViewpointDefinition` must subclass, directly or indirectly, the base `ViewpointDefinition` `Viewpoint` from the Systems model library.

General Classes

`RequirementDefinition`

Attributes

No attributes.

Operations

No operations.

Constraints

No constraints.

7.20.3.8 ViewpointUsage

Description

A ViewpointUsage is a usage of a ViewpointDefinition.

A ViewpointUsage must subset, directly or indirectly, the base ViewpointUsage viewpoints from the Systems model library.

General Classes

RequirementUsage

Attributes

/viewpointDefinition : ViewpointDefinition {redefines requirementDefinition}

The ViewpointDefinition that defines this ViewUsage.

Operations

No operations.

Constraints

No constraints.

7.20.3.9 ViewUsage

Description

A ViewUsage is a usage of a ViewDefinition to specify the generation of a view of a specific exposedPackage. The ViewDefinition can satisfy more viewpoints than its definition, and it can specialize the rendering specified by its definition.

A ViewUsage must subset, directly or indirectly, the base ViewUsage views from the Systems model library.

General Classes

PartUsage

Attributes

/exposedPackage : Package [0..*]

The Package that is exposed by this ViewUsage, derived as the `importedPackage` related to the ViewUsage by a Expose Relationship.

`/rendering : RenderingUsage [0..1] {subsets nestedUsage}`

The RenderingUsage to be used to render the view specified by this ViewUsage.

`/satisfiedViewpoint : ViewpointUsage [0..*] {subsets nestedUsage}`

The `nestedUsages` of this ViewUsage that are ViewpointUsages for (additional) viewpoints satisfied by the ViewUsage.

`/viewDefinition : ViewDefinition {redefines partDefinition}`

The definition of this ViewUsage.

Operations

No operations.

Constraints

No constraints.

7.20.4 Views Semantics

7.21 Language Extension

Submission Note. SysML v2 will include the ability to extend the language, in a similar way to which SysML is build on KerML. This will be fully addressed in the revised submission.

8 Model Libraries

Submission Note. The documentation provided in this clause is currently incomplete. Please refer to the textual notation files for the normative representation of all library models. Currently, the only domain library included is for Quantities and Units. Additional domain libraries are planned for the revised submission, at least for Basic Geometry.

8.1 Systems Model Library

8.1.1 Overview

8.1.2 Attributes

8.1.2.1 Attributes Overview

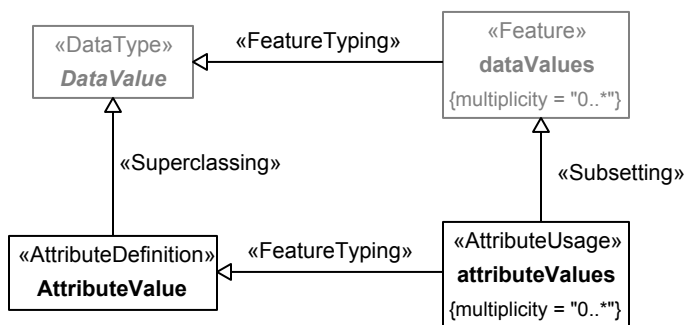


Figure 61. Attributes Model Library

8.1.2.2 Elements

8.1.2.2.1 attributeValues <AttributeUsage>

Description

attributeValues is the base feature for all AttributeUsages.

General Classes

AttributeValue
dataValues

Attributes

No attributes.

Constraints

No constraints.

8.1.2.2.2 AttributeValue <AttributeDefinition>

Description

AttributeValue is the most general type of data values that represent qualities or characteristics of a system or part of a system. AttributeValue is the base type of all AttributeDefinitions.

General Classes

DataValue

Attributes

No attributes.

Constraints

No constraints.

8.1.3 Items

8.1.3.1 Items Overview

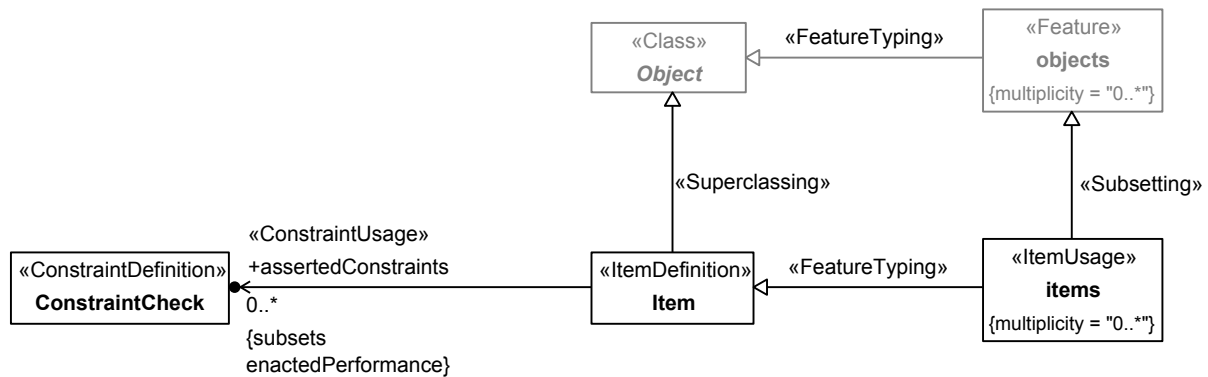


Figure 62. Items Model Library

8.1.3.2 Elements

8.1.3.2.1 Item <ItemDefinition>

Description

Item is the most general class of objects that are part of, exist in or flow through a system. Item is the base type of all ItemDefinitions.

General Classes

Object

Attributes

assertedConstraints : ConstraintCheck [0..*] {subsets enactedPerformance}

Constraints

No constraints.

8.1.3.2.2 items <ItemUsage>

Description

items is the base feature of all ItemUsages.

General Classes

objects
Item

Attributes

No attributes.

Constraints

No constraints.

8.1.4 Parts

8.1.4.1 Parts Overview

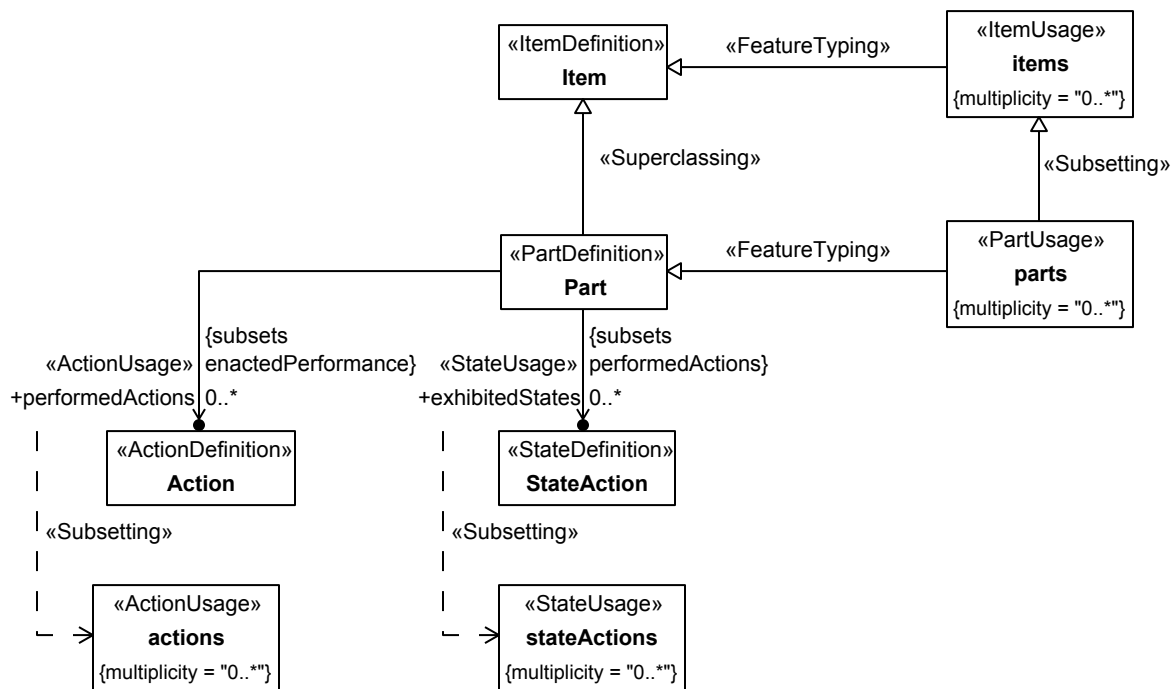


Figure 63. Parts Library Model

8.1.4.2 Elements

8.1.4.2.1 Part <PartDefinition>

Description

Part is the most general class of objects that represent all or a part of a system. Part is the base type of all PartDefinitions.

General Classes

Item

Attributes

exhibitedStates : StateAction [0..*] {subsets performedActions}

performedActions : Action [0..*] {subsets enactedPerformance}

Actions that are performed by this part.

Constraints

No constraints.

8.1.4.2.2 parts <PartUsage>

Description

parts is the base feature of all PartUsages.

General Classes

Part
items

Attributes

No attributes.

Constraints

No constraints.

8.1.5 Ports

8.1.5.1 Ports Overview

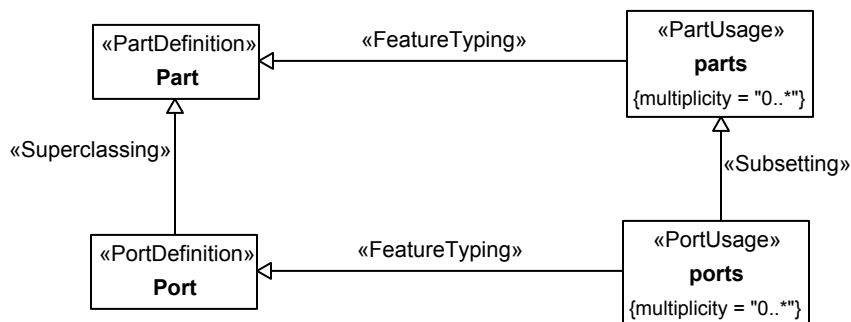


Figure 64. Ports Library Model

8.1.5.2 Elements

8.1.5.2.1 Port <PortDefinition>

Description

Port is the most general class of objects that represent connection points for interacting with a Part. Port is the base type of all PortDefinitions.

General Classes

Part

Attributes

No attributes.

Constraints

No constraints.

8.1.5.2.2 ports <PortUsage>

Description

ports is the base feature of all PortUsages.

General Classes

Port
parts

Attributes

No attributes.

Constraints

No constraints.

8.1.6 Connections

8.1.6.1 Connections Overview

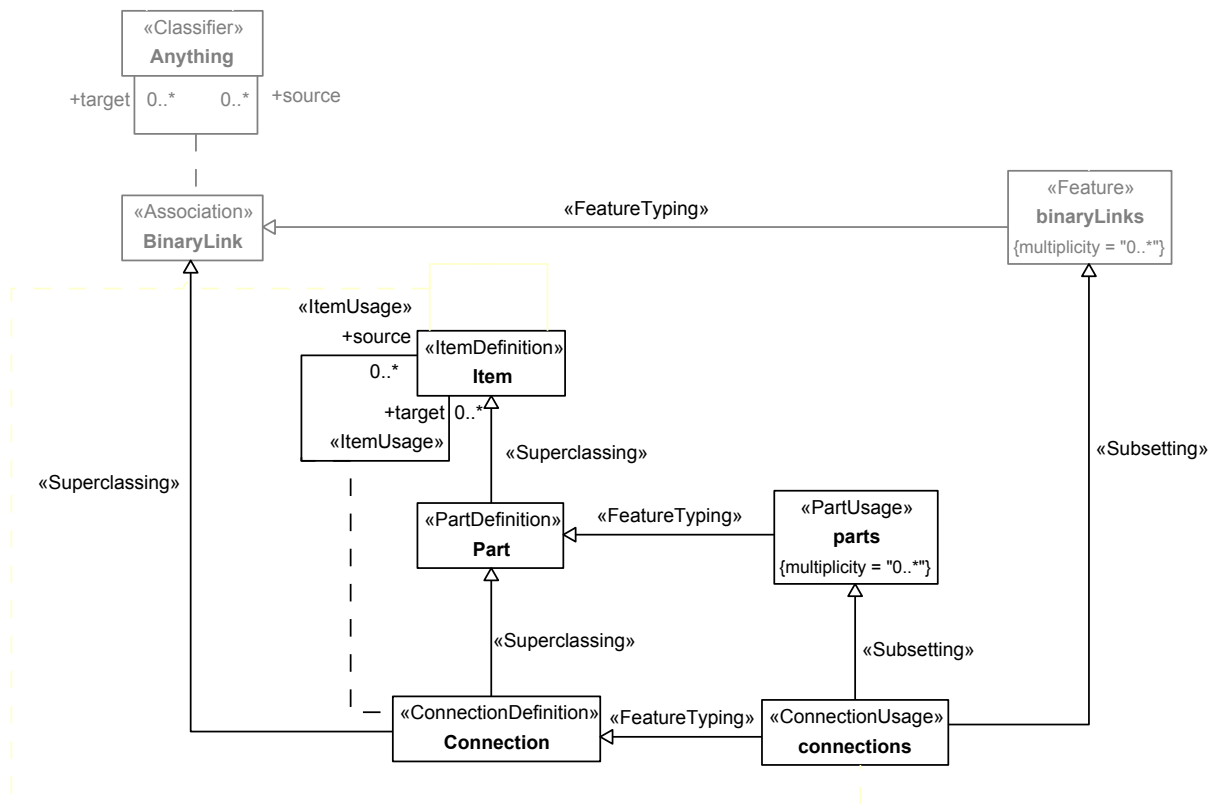


Figure 65. Connections Library Model

8.1.6.2 Elements

8.1.6.2.1 Connection <ConnectionDefinition>

Description

Connection is the most general class of connections between two Parts within some containing structure. Connection is the base type of all ConnectionDefinitions.

(Note that this does not include BindingConnectors, which are typed by the kernel Association SelfLink.)

General Classes

Part
BinaryLink

Attributes

source : Item [0..*]

target : Item [0..*]

Constraints

No constraints.

8.1.6.2.2 connections <ConnectionUsage>

Description

connections is the base feature of all ConnectionUsages.

General Classes

parts

Connection

binaryLinks

Attributes

[no name] : Item

[no name] : Item

Constraints

No constraints.

8.1.7 Interfaces

8.1.7.1 Interfaces Overview

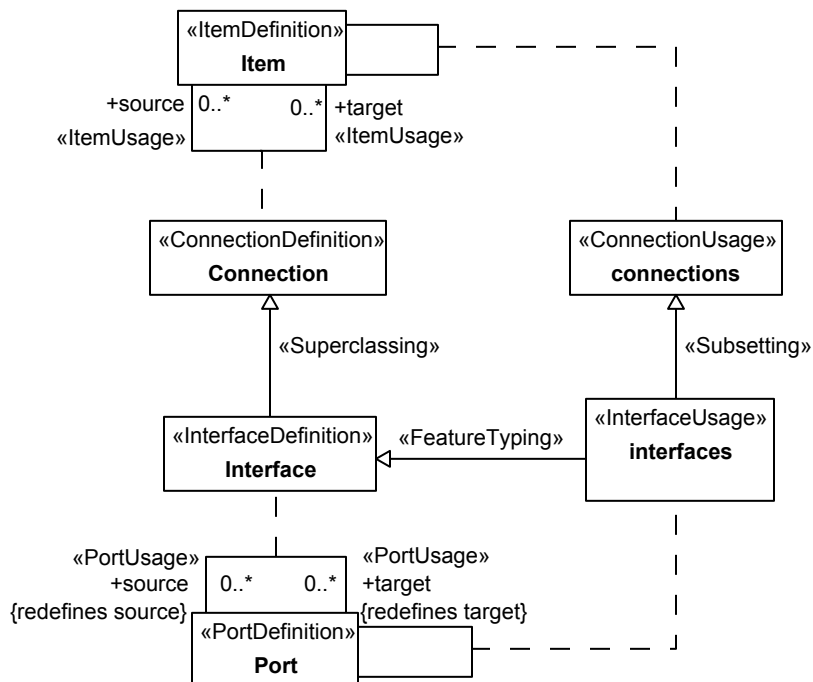


Figure 66. Interfaces Library Model

8.1.7.2 Elements

8.1.7.2.1 Interface <InterfaceDefintion>

Description

Interface is the most general class of connections between two Ports on Parts within some containing structure. Interface is the base type of all InterfaceDefinitions.

General Classes

Connection

Attributes

source : Port [0..*] {redefines source}

target : Port [0..*] {redefines target}

Constraints

No constraints.

8.1.7.2.2 interfaces <InterfaceUsage>

Description

`interfaces` is the base feature of all InterfaceUsages.

General Classes

Interface
connections

Attributes

[no name] : Port

[no name] : Port

Constraints

No constraints.

8.1.8 Actions

8.1.8.1 Actions Overview

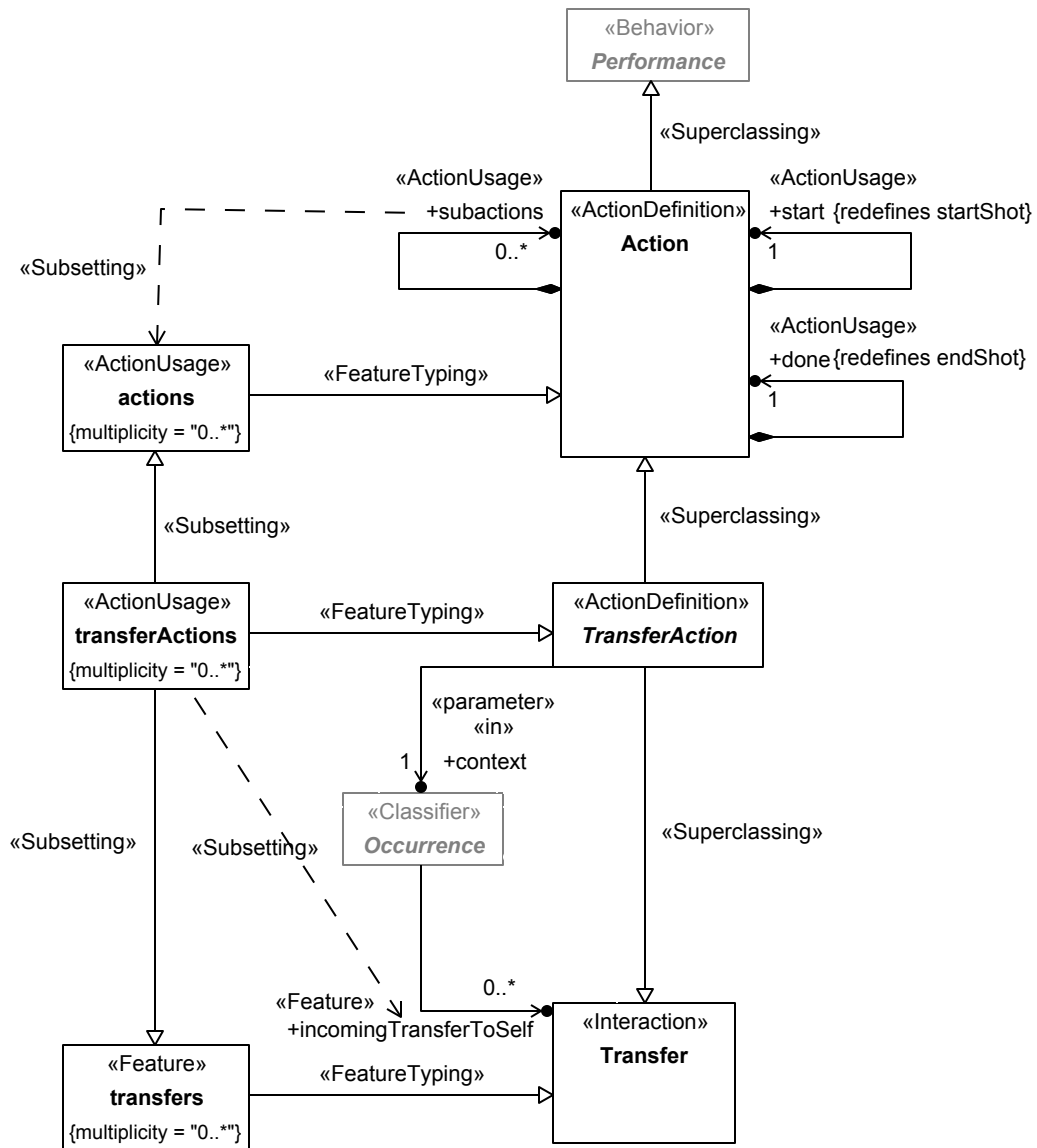


Figure 67. Actions Library Model

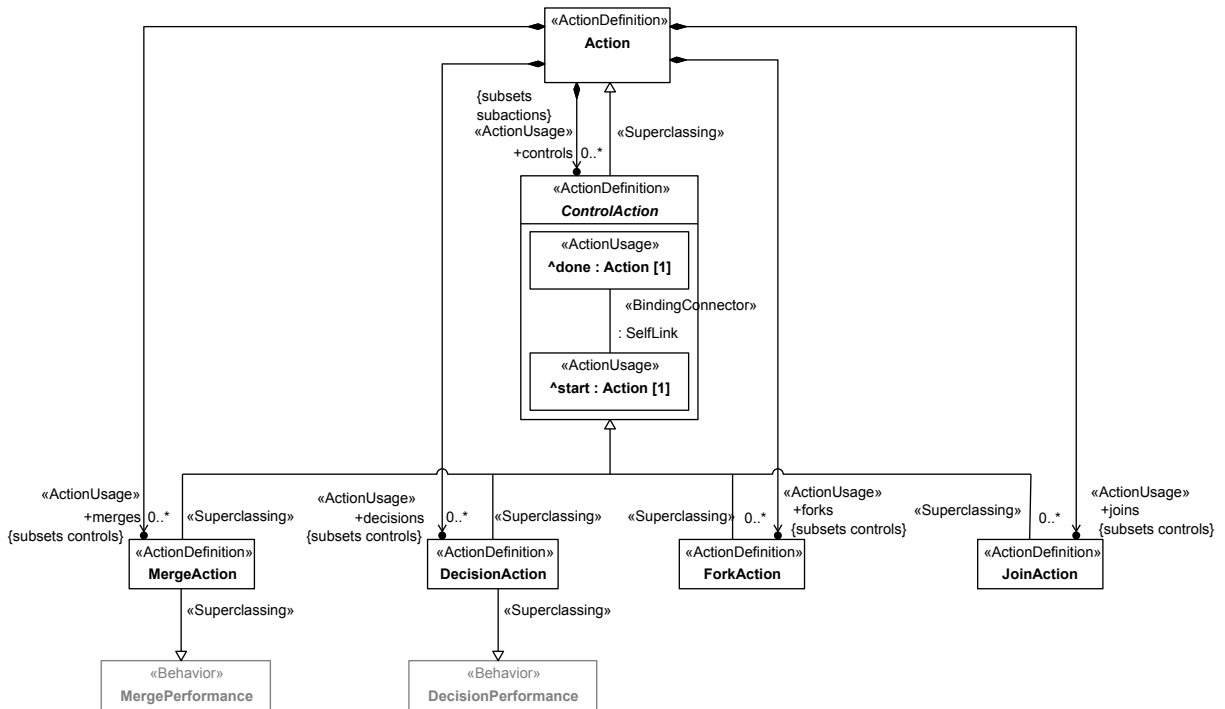


Figure 68. Control Nodes Library Model

8.1.8.2 Elements

8.1.8.2.1 Action <ActionDefintion>

Description

Action is the most general class of performances of ActionDefinitions in a system or part of a system. Action is the base class of all ActionDefinitions.

General Classes

Performance

Attributes

controls : ControlAction [0..*] {subsets subactions}

The subactions of this activity that are control actions.

decisions : DecisionAction [0..*] {subsets controls}

The control actions of this activity that are decision actions.

done : Action {redefines endShot}

The ending snapshot of an action.

forks : ForkAction [0..*] {subsets controls}

The control actions of this activity that are fork actions.

joins : JoinAction [0..*] {subsets controls}

The control actions of this activity that are join actions.

merges : MergeAction [0..*] {subsets controls}

The control actions of this activity that are merge actions.

start : Action {redefines startShot}

The starting snapshot of an action.

subactions : Action [0..*]

The subperformances of this action that are actions.

subtransitions : TransitionAction [0..*]

Constraints

No constraints.

8.1.8.2.2 actions <ActionUsage>

Description

actions is the base feature for all ActionUsages.

General Classes

Action

Attributes

No attributes.

Constraints

No constraints.

8.1.8.2.3 ControlAction <ActionDefinition>

Description

A ControlAction is the Action of a ControlNode, which has no inherent behavior.

General Classes

Action

Attributes

No attributes.

Constraints

No constraints.

8.1.8.2.4 DecisionAction <ActionDefinition>

Description

A DecisionAction is the ControlAction for a DecisionNode. It is a DecisionPerformance that selects one outgoing HappensBeforeLink.

General Classes

DecisionPerformance
ControlAction

Attributes

No attributes.

Constraints

No constraints.

8.1.8.2.5 ForkAction <ActionDefinition>

Description

A ForkAction is the ControlAction for a ForkNode.

Note: Fork behavior results from requiring that the target multiplicity of all outgoing succession connectors be 1..1.

General Classes

ControlAction

Attributes

No attributes.

Constraints

No constraints.

8.1.8.2.6 JoinAction <ActionDefinition>

Description

A JoinAction is the ControlAction for a JoinNode.

Note: Join behavior results from requiring that the source multiplicity of all incoming succession connectors be 1..1.

General Classes

ControlAction

Attributes

No attributes.

Constraints

No constraints.

8.1.8.2.7 MergeAction <ActionDefinition>

Description

A MergeAction is the ControlAction for a merge node. It is a MergePerformance that selects exactly one incoming HappensBefore link.

General Classes

ControlAction
MergePerformance

Attributes

No attributes.

Constraints

No constraints.

8.1.9 States

8.1.9.1 States Overview

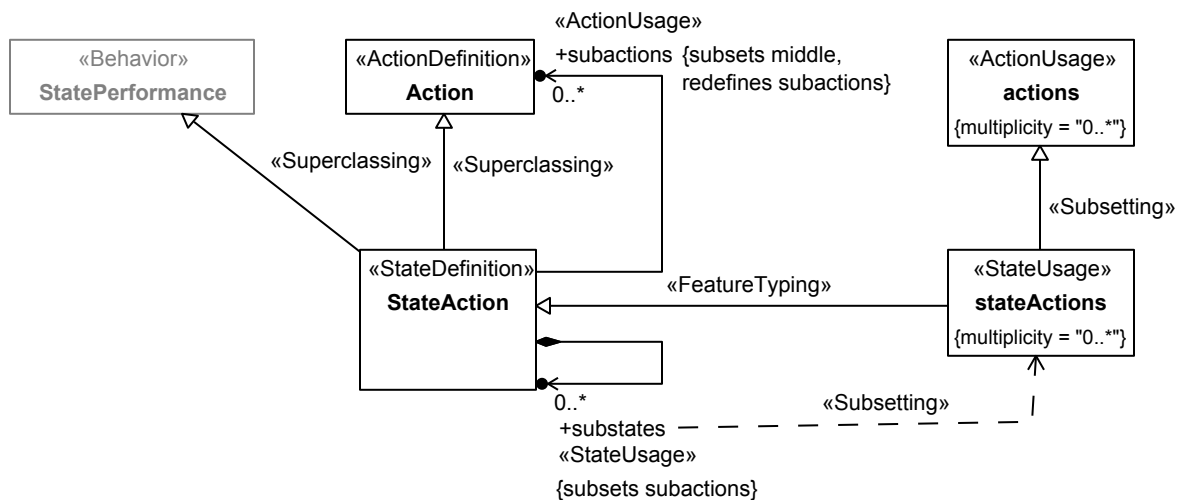


Figure 69. States Library Model

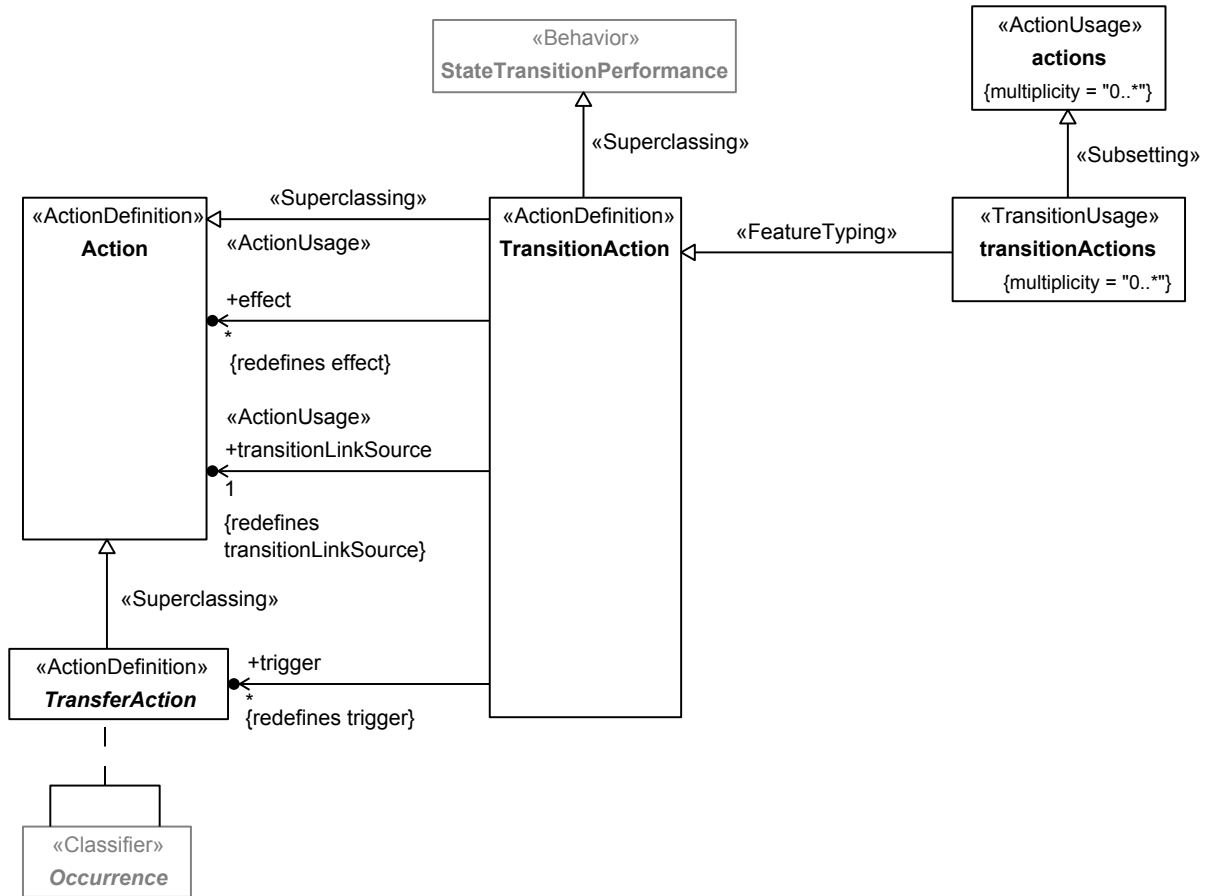


Figure 70. Transitions Library Model

8.1.9.2 Elements

8.1.9.2.1 StateAction <StateDefinition>

Description

A StateAction is a kind of Action that is also a StatePerformance. It is the base type for all StateDefinitions.

General Classes

StatePerformance
Action

Attributes

subactions : Action [0..*] {subsets middle, redefines subactions}

The subperformances of this StateAction that are Actions, other than the entry and exit Actions. These subactions all take place in the "middle" of the StatePerformance, that is, after the entry Action and before the exit Action.

substates : StateAction [0..*] {subsets subactions}

The `subactions` of this `StateAction` that are `StateActions`. These `substates` all take place in the "middle" of the `StatePerformance`, that is, after the entry `Action` and before the exit `Action`.

Constraints

No constraints.

8.1.9.2.2 stateActions <StateUsage>

Description

`stateActions` is the base feature for all `StateUsages`.

General Classes

`actions`
`StateAction`

Attributes

No attributes.

Constraints

No constraints.

8.1.9.2.3 TransitionAction <ActionDefintion>

Description

A `Transition` is a `StateTransitionPerformance` whose `transitionLinkSource` is an `Action`.

General Classes

`StateTransitionPerformance`
`Action`

Attributes

`effect` : `Action` [0..*] {redefines `effect`}

`transitionLinkSource` : `Action` {redefines `transitionLinkSource`}

`trigger` : `TransferAction` [0..*] {redefines `trigger`}

Constraints

No constraints.

8.1.9.2.4 transitionActions <TransitionUsage>

Description

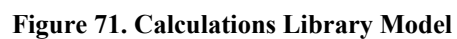
`transitions` is the base feature for all `Transition` usages.

actions
Action
TransitionAction

No attributes.

No constraints.

8.1.10.1 Calculations Overview



8.1.10.2.1 Calculation <CalculationDefinition>

Calculation is the most general class of evaluations of CalculationDefinitions in a system or part of a system. Calculation is the base class of all CalculationDefinitions.

252

Action
Evaluation

Attributes

subcalculations : Calculation [0..*] {subsets subactions}

The subactions of this FunctionInvocation that are FunctionInvocations.

Constraints

No constraints.

8.1.10.2.2 calculations <CalculationUsage>

Description

calculations is the base Feature for all CalculationUsages.

.

General Classes

Calculation
actions
evaluations

Attributes

No attributes.

Constraints

No constraints.

8.1.11 Constraints

8.1.11.1 Constraints Overview

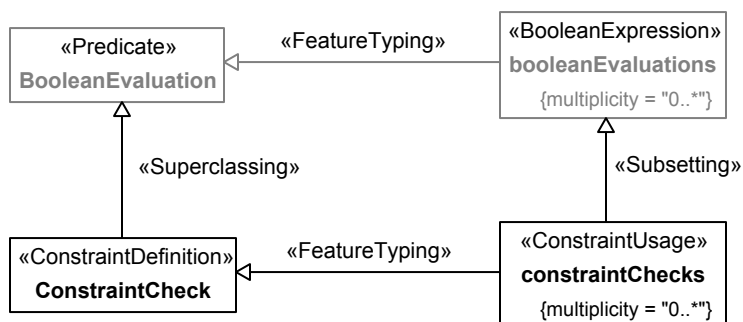


Figure 72. Constraints Library Model

8.1.11.2 Elements

8.1.11.2.1 ConstraintCheck <ConstraintDefinition>

Description

ConstraintCheck is the most general class for constraint checking. ConstraintCheck is the base type of all ConstraintDefinitions.

General Classes

BooleanEvaluation

Attributes

No attributes.

Constraints

No constraints.

8.1.11.2.2 constraintChecks <ConstraintUsage>

Description

constraintChecks is the base feature of all ConstraintUsages.

General Classes

booleanEvaluations

ConstraintCheck

Attributes

No attributes.

Constraints

No constraints.

8.1.12 Requirements

8.1.12.1 Requirements Overview

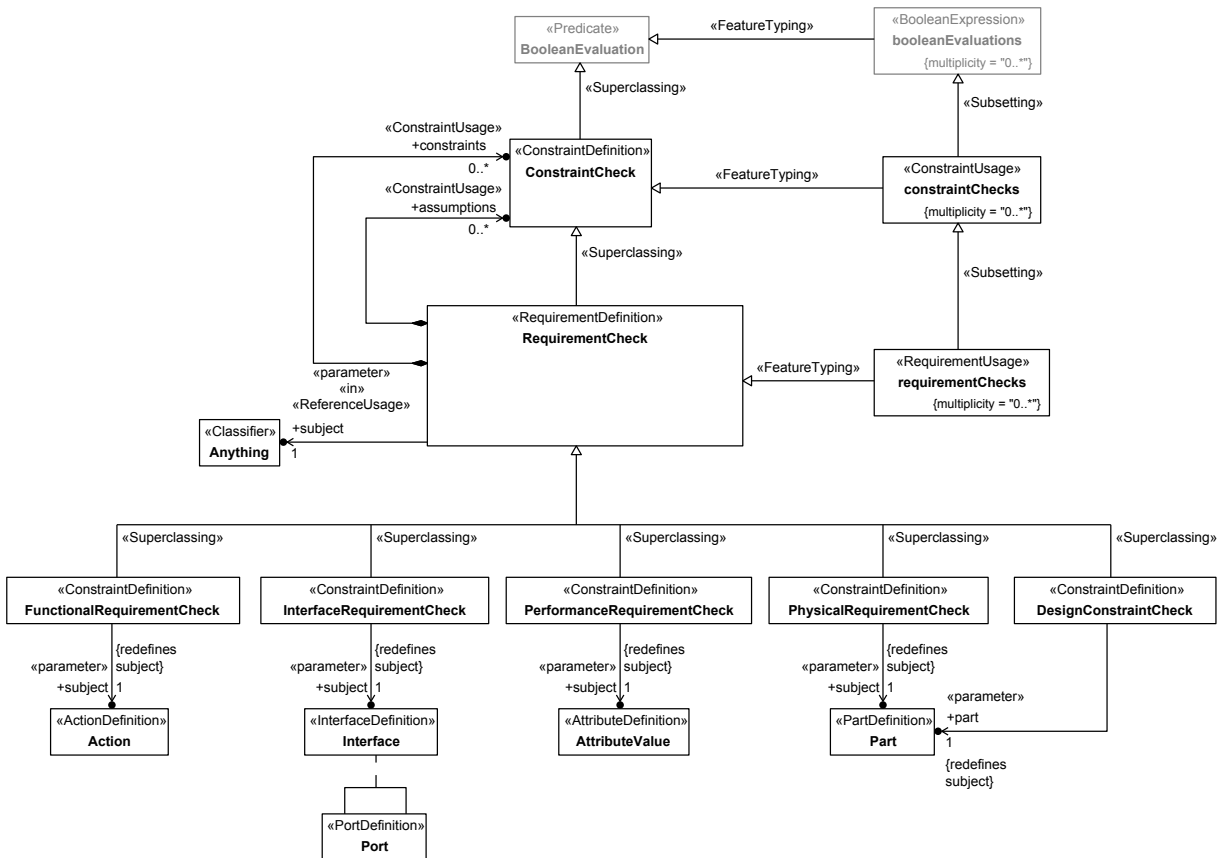


Figure 73. Requirements Library Model

8.1.12.2 Elements

8.1.12.2.1 DesignConstraintCheck <ConstraintDefinition>

Description

A DesignConstraint specifies a constraint on the implementation of the system or system part, such as the system must use a commercial-off-the-shelf component.

General Classes

RequirementCheck

Attributes

part : Part {redefines subject}

Constraints

No constraints.

8.1.12.2.2 FunctionalRequirementCheck <ConstraintDefinition>

Description

A FunctionalRequirementCheck specifies an action that a system, or part of a system, must perform.

General Classes

RequirementCheck

Attributes

subject : Action {redefines subject}

Constraints

No constraints.

8.1.12.2.3 InterfaceRequirementCheck <ConstraintDefinition>

Description

An InterfaceRequirement Check specifies an Interface for connecting systems and system parts, which optionally may include item flows across the Interface and/or Interface constraints.

General Classes

RequirementCheck

Attributes

subject : Interface {redefines subject}

Constraints

No constraints.

8.1.12.2.4 PerformanceRequirementCheck <ConstraintDefinition>

Description

A PerformanceRequirementCheck quantitatively measures the extent to which a system, or a system part, satisfies a required capability or condition.

General Classes

RequirementCheck

Attributes

subject : AttributeValue {redefines subject}

Constraints

No constraints.

8.1.12.2.5 PhysicalRequirementCheck <ConstraintDefinition>

Description

A PhysicalRequirementCheck specifies physical characteristics and/or physical constraints of the system, or a system part.

General Classes

RequirementCheck

Attributes

subject : Part {redefines subject}

Constraints

No constraints.

8.1.12.2.6 RequirementCheck <RequirementDefinition>

Description

RequirementCheck is the most general class for requirements checking. RequirementCheck is the base type of all RequirementDefinitions.

General Classes

ConstraintCheck

Attributes

assumptions : ConstraintCheck [0..*]

Assumptions that must hold for the required constraints to apply.

constraints : ConstraintCheck [0..*]

The required constraints that are to be checked.

subject : Anything

The entity that is being checked for satisfaction of the required constraints.

Constraints

[no name]

[no documentation]

`allTrue(assumptions) implies allTrue(constraints)`

8.1.12.2.7 requirementChecks <RequirementUsage>

Description

requirementChecks is the base feature of all requirement usages.

General Classes

RequirementCheck
constraintChecks

Attributes

No attributes.

Constraints

No constraints.

8.1.13 Cases

8.1.13.1 Cases Overview

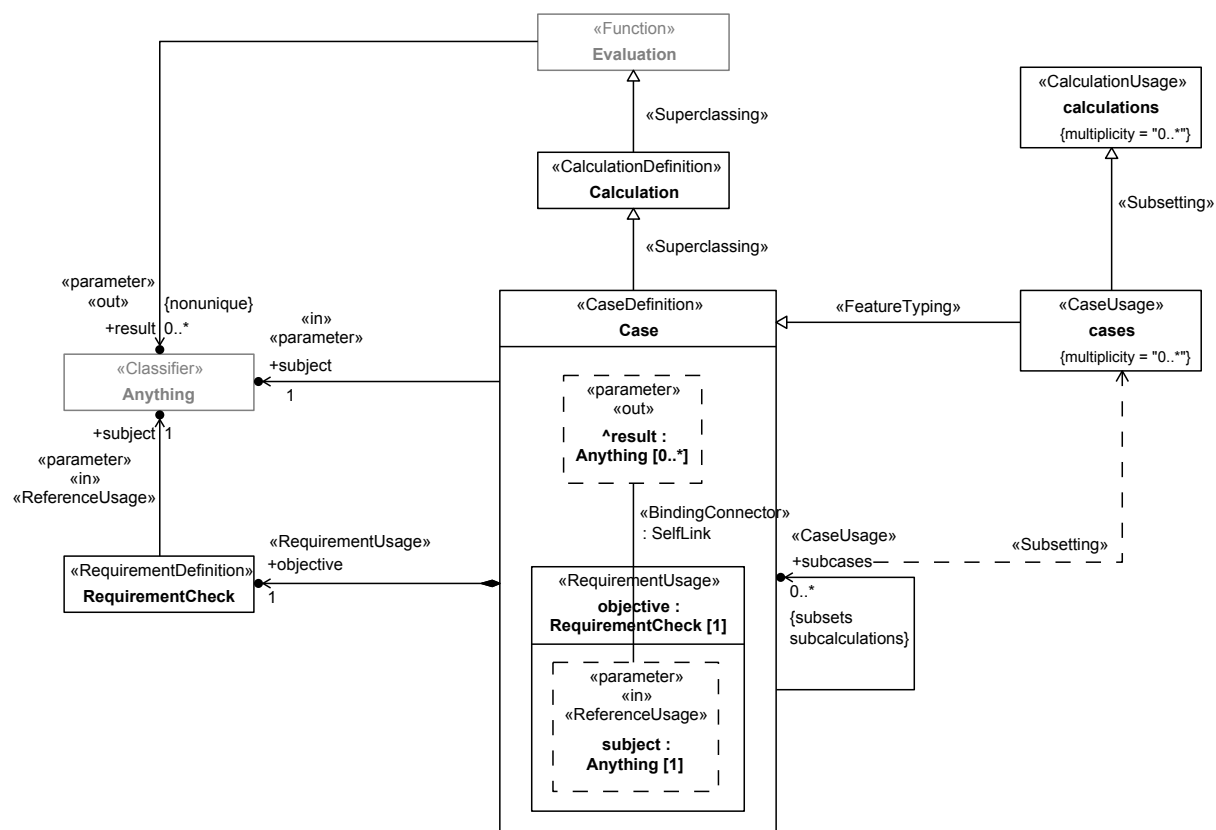


Figure 74. Cases Library Model

8.1.13.2 Elements

8.1.13.2.1 Case <CaseDefinition>

Description

Case is the most general class of performances of CaseDefinitions. Case is the base class of all CaseDefinitions.

General Classes

Calculation

Attributes

objective : RequirementCheck

A check of whether the objective RequirementUsage was satisfied for this Case.

subcases : Case [0..*] {subsets subcalculations}

Other Cases carried out as part of the performance of this Case.

subject : Anything

The subject that was investigated by this Case.

Constraints

No constraints.

8.1.13.2.2 cases <CaseUsage>

Description

cases is the base feature of all CaseUsages.

General Classes

calculations

Case

Attributes

No attributes.

Constraints

No constraints.

8.1.14 Analysis Cases

8.1.14.1 Analysis Cases Overview

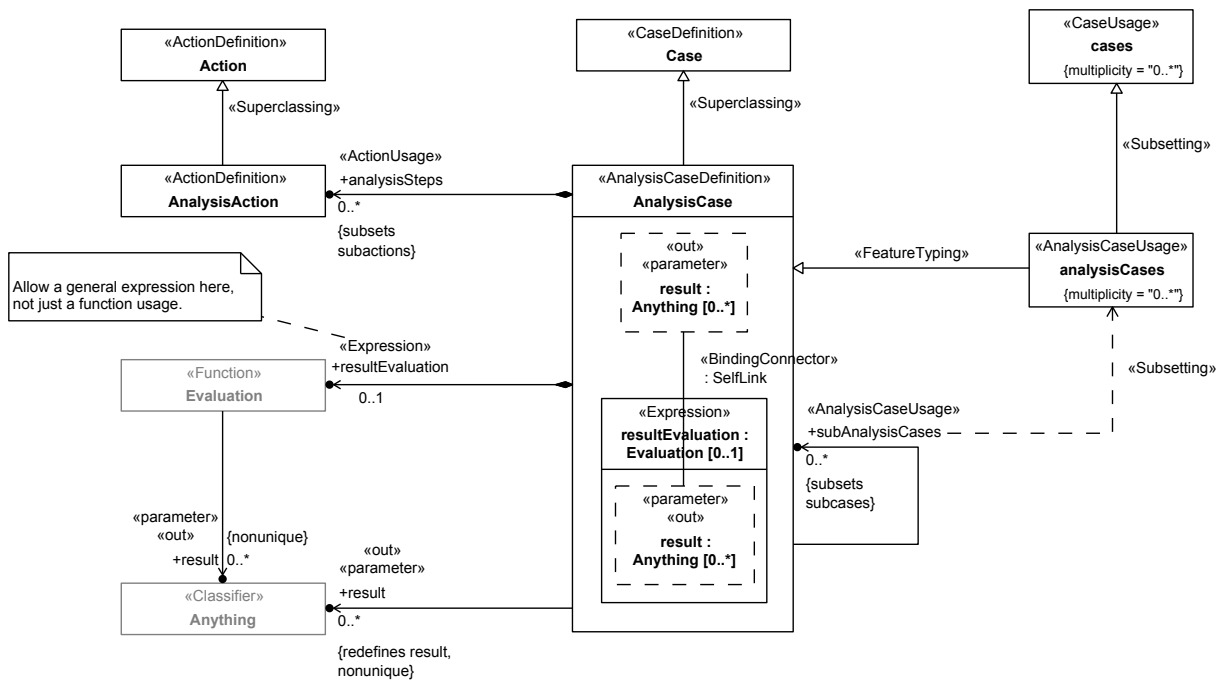


Figure 75. Analysis Case Library Model

8.1.14.2 Elements

8.1.14.2.1 AnalysisAction <ActionDefinition>

Description

An AnalysisAction is a specialized kind of Action used intended to be used as a step in an AnalysisCase.

General Classes

Action

Attributes

No attributes.

Constraints

No constraints.

8.1.14.2.2 AnalysisCase <AnalysisCaseDefinition>

Description

AnalysisCase is the most general class of performances of AnalysisCaseDefinitions. AnalysisCase is the base class of all AnalysisCaseDefinitions.

General Classes

Case

Attributes

`analysisSteps` : `AnalysisAction` [0..*] {subsets subactions}

The `subactions` of this `AnalysisCase` that are `AnalysisActions`.

`result` : `Anything` [0..*] {redefines result, nonunique}

The result of this `AnalysisCase`, which is bound to the `result` of the `resultEvaluation`.

`resultEvaluation` : `Evaluation` [0..1]

The `Evaluation` of the `resultExpression` from the definition of this `AnalysisCase`.

`subAnalysisCases` : `AnalysisCase` [0..*] {subsets subcases}

The `subcases`

of this `AnalysisCase` that are `AnalysisCaseUsages`.

Constraints

No constraints.

8.1.14.2.3 `analysisCases` <`AnalysisCaseUsage`>

Description

`analysisCases` is the base feature of all `AnalysisCaseUsages`.

General Classes

`AnalysisCase`
`cases`

Attributes

No attributes.

Constraints

No constraints.

8.1.15 Verification Cases

8.1.15.1 Verification Cases Overview

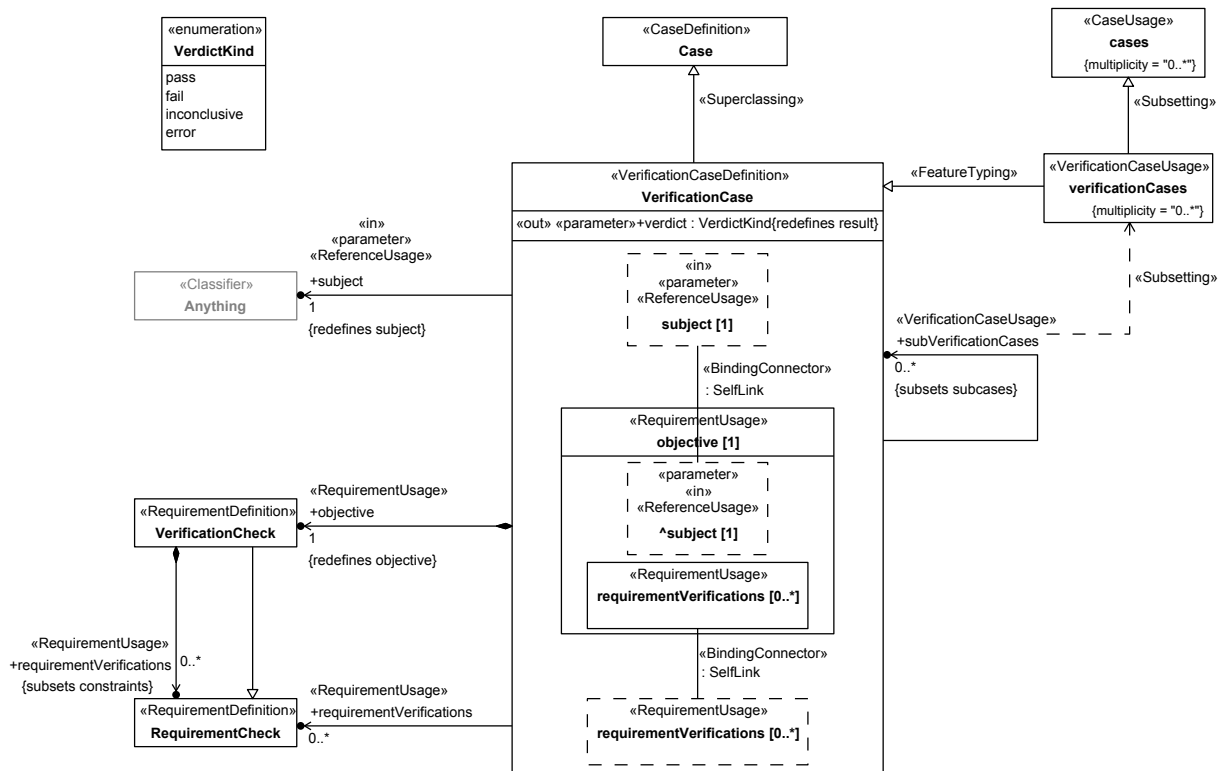


Figure 76. Verification Case Library Model

8.1.15.2 Elements

8.1.15.2.1 VerdictKind <Enumeration>

Description

VerdictKind is an enumeration of the possible results of a VerificationCase.

General Classes

No general classes.

Literal Values

error

An error occurred while evaluating the ValidationCase.

fail

The VerificationCase failed to achieve its objective.

inconclusive

The result of the VerificationCase was inconclusive.

pass

The VerificationCase passed, achieving its objective.

8.1.15.2.2 VerificationCase <VerificationCaseDefinition>

Description

VerificationCase is the most general class of performances of VerificationCaseDefinitions. VerificationCase is the base class of all VerificationCaseDefinitions.

General Classes

Case

Attributes

objective : VerificationCheck {redefines objective}

The objective this VerificationCase, whose `subject` is bound to the `subject` of the VerificationCase and whose `requirementVerifications` are bound to the `requirementVerifications` of the VerificationCase.

requirementVerifications : RequirementCheck [0..*]

Checks on whether the `verifiedRequirements` of the VerificationCase have been satisfied.

subject : Anything {redefines subject}

The subject of this VerificationCase, representing the system under test, which is bound to the `subject` of the `objective` of the VerificationCase.

subVerificationCases : VerificationCase [0..*] {subsets subcases}

The subcases

of this VerificationCase that are VerificationCaseUsages.

verdict : VerdictKind {redefines result}

The result of a VerificationCase must be a VerdictKind.

Constraints

No constraints.

8.1.15.2.3 verificationCases <VerificationCaseUsage>

Description

verificationCases is the base feature of all VerificationCaseUsages.

General Classes

VerificationCase
cases

Attributes

No attributes.

Constraints

No constraints.

8.1.15.2.4 VerificationCheck <RequirementDefinition>

Description

VerificationCheck is a specialization of RequirementCheck used for the `objective` of a VerificationCase in order to record the evaluations of the RequirementChecks of requirements being verified.

General Classes

RequirementCheck

Attributes

requirementVerifications : RequirementCheck [0..*] {subsets constraints}

Constraints

No constraints.

8.1.16 Views

8.1.16.1 Views Overview

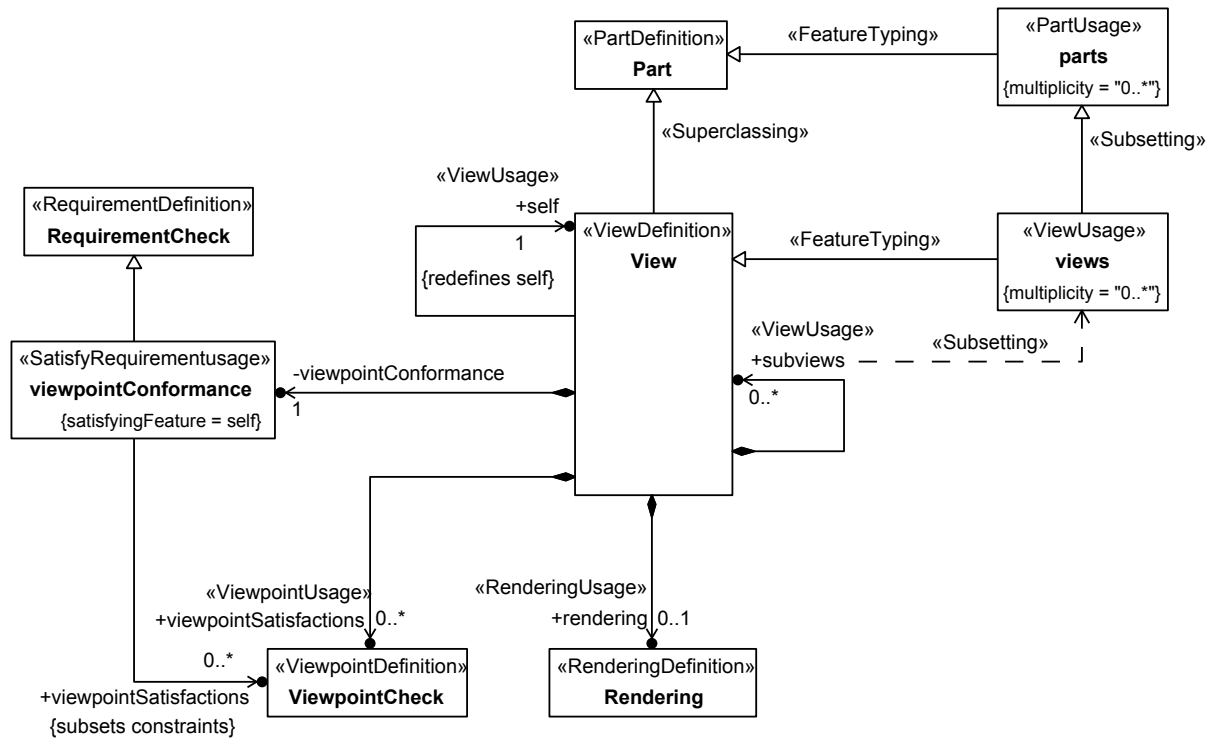


Figure 77. Views Library Model

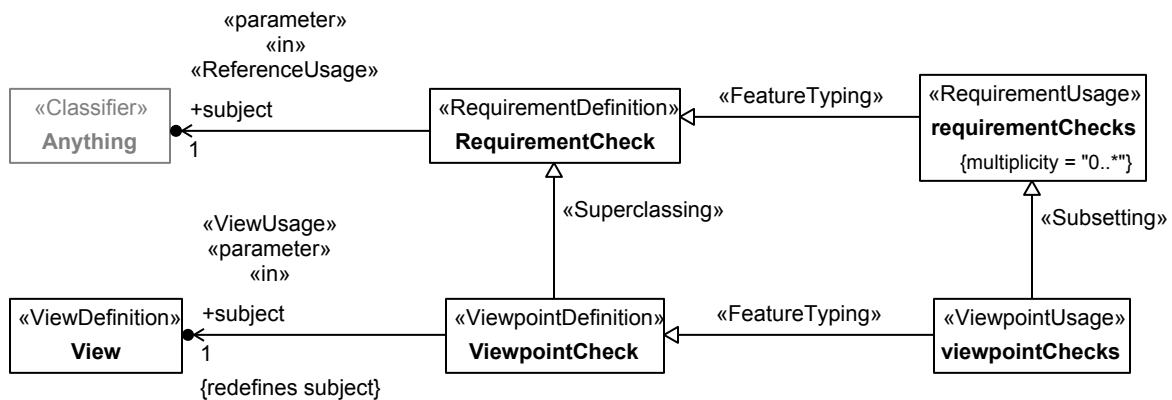


Figure 78. Viewpoints Library Model

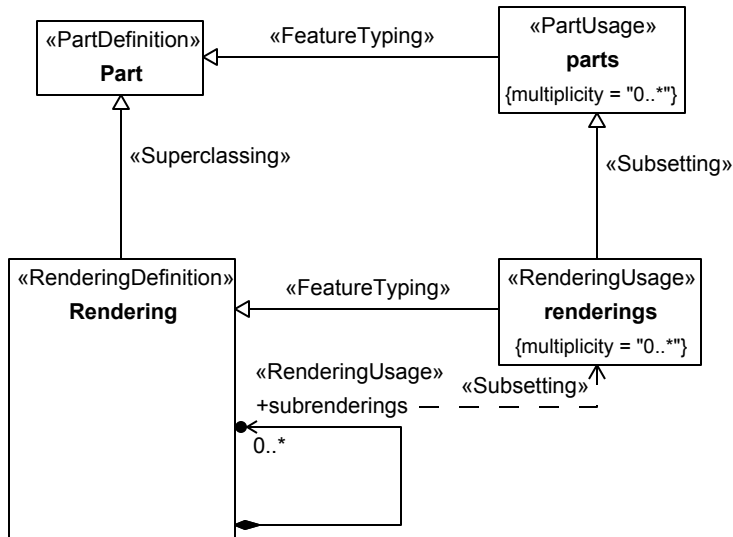


Figure 79. Renderings Library Model

8.1.16.2 Elements

8.1.16.2.1 Rendering <RenderingDefinition>

Description

Rendering is the base type of all RenderingDefinitions.

General Classes

Part

Attributes

subrenderings : Rendering [0..*]

Other Renderings used to carry out this Rendering.

Constraints

No constraints.

8.1.16.2.2 renderings <RenderingUsage>

Description

renderings is the base feature of all RenderingUsages.

General Classes

Rendering
parts

Attributes

No attributes.

Constraints

No constraints.

8.1.16.2.3 View <ViewDefinition>

Description

View is the base type of all ViewDefinitions.

General Classes

Part

Attributes

rendering : Rendering [0..1]

The Rendering of this View.

self : View {redefines self}

subviews : View [0..*]

Other Views that are used in the rendering of this View.

viewpointConformance : viewpointConformance

An assertion that all viewpointSatisfactions are true.

viewpointSatisfactions : ViewpointCheck [0..*]

Checks that the View satisfies all required ViewpointsUsages.

Constraints

No constraints.

8.1.16.2.4 ViewpointCheck <ViewpointDefinition>

Description

ViewpointCheck is a RequirementCheck for checking if a View meets the concerns of viewpoint stakeholders. It is the base type of all ViewpointDefinitions.

General Classes

RequirementCheck

Attributes

subject : View {redefines subject}

The subject of this ViewpointCheck, which must be a View.

Constraints

No constraints.

8.1.16.2.5 viewpointChecks <ViewpointUsage>

Description

viewpointChecks

is the base feature of all ViewpointUsages.

General Classes

ViewpointCheck
requirementChecks

Attributes

No attributes.

Constraints

No constraints.

8.1.16.2.6 viewpointConformance <SatisfyRequirementUsage>

Description

General Classes

RequirementCheck

Attributes

viewpointSatisfactions : ViewpointCheck [0..*] {subsets constraints}

The required ViewpointChecks.

Constraints

No constraints.

8.1.16.2.7 views <ViewUsage>

Description

views is the base feature of all ViewUsages.

General Classes

parts
View

Attributes

No attributes.

Constraints

No constraints.

8.2 Quantities and Units Model Library

8.2.1 Overview

The Quantities and Values packages contain syntax and semantics to support well-defined engineering quantities as well as systems of units and non-scalar values.

For any system model, a solid foundation for the representation of quantities, measurement units and scales, quantity dimensions, coordinate systems as well as value conversions is essential. Quantity attributes are needed to specify many characteristics of a system of interest. The foundation should be a shareable resource that can be reused in models within and across organizations and projects in order to facilitate collaboration and model interoperability.

The most widely accepted, scrutinized, and globally used foundational collection of quantities and units is captured and maintained in:

- the International System of Quantities (ISQ)
- the International System of Units (SI)

These systems are formally standardized through the ISO/IEC 80000 series of standards. The top level concepts and semantics defined in this model library are derived from and mapped to the concepts and semantics specified in [ISO 80000-1] and [VIM], as directly as possible, but staying at a generic level. This enables representing the ISQ and SI, but also any other systems of quantities and units.

The data model in this library includes precise representation and unambiguous semantics of the relationships between quantities, units, scales and quantity dimensions. As a result, robust automated conversion between quantity values expressed in compatible measurement units or scales is enabled, as well as support for quantity dimension analysis of expressions and constraints.

The model library further contains lower level packages that represent actual quantities and units as specified in parts 3 to 14 of the ISO/IEC 80000 series. These packages are intended to be used as a basis, and then be extended and tailored for use by particular communities of practitioners and organizations.

Apart from SI, the system of US Customary Units is still in wide industrial use. In order to support this system, the library also contains a package of US Customary Units, their relationship with ISQ quantities, and their conversion factors to and from SI units as specified in [NIST SP-811].

8.2.2 Quantities

8.2.2.1 Quantities Overview

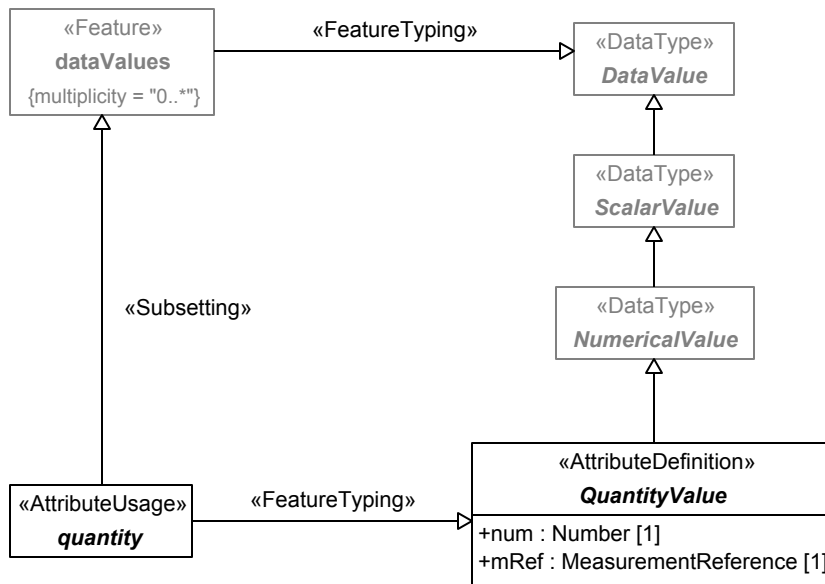


Figure 80. Quantity Values and Features

A quantity is modeled as a self-standing abstract `quantity`, that is typed by `QuantityValue` and can be further specialized for any needed type of quantity, e.g. `length` typed by `LengthValue` and `mass` typed by `MassValue`.

Any quantity is modeled as a self-standing abstract `quantity` `<AttributeUsage>`, that is typed by `QuantityValue` and can be further specialized for any needed type of quantity, e.g. `length` typed by `LengthValue` and `mass` typed by `MassValue`.

Clause 1.1 of the [VIM] defines quantity as: "property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference". The reference is further defined to be "a measurement unit, a measurement procedure, a reference material, or a combination of such". This notion of a quantity and its value is represented as follows hereafter.

The value of a quantity is modeled as an abstract `QuantityValue` `<AttributeDefinition>` that is a tuple of a `Number` (i.e. a mathematical number value), `num`, and a reference to a `MeasurementReference`, `mRef`. `QuantityValue` can be further specialized to represent any more concrete kind of value, e.g. `LengthValue` and `MassValue`.

8.2.2.2 Elements

8.2.2.2.1 QuantityValue <AttributeDefinition>

Description

A `QuantityValue` is an `AttributeDefinition` that represents the value of a quantity by a tuple of a `Number` and a reference to a `MeasurementReference`.

General Classes

`NumericalValue`

Attributes

mRef : MeasurementReference

Attribute mRef is the MeasurementReference for this QuantityValue.

num : Number

Attribute num is the Number value of this QuantityValue.

Typically this will be a Real number.

Constraints

No constraints.

8.2.2.2.2 quantity <AttributeUsage>

Description

A quantity is an AttributeUsage that is a self-standing attribute. Specializations of quantity are used to create all particular quantities needed to characterize model objects.

Modeling quantity and its specializations like e.g. length and mass as self-standing attributes allows to create a library of pre-defined kinds of quantity for direct use as well as extension. It helps to establish and maintain uniform quantity naming across models. This in turn facilitates model interoperability at the end-user level.

General Classes

QuantityValue
dataValues

Attributes

No attributes.

Constraints

No constraints.

8.2.3 Units and Scales

8.2.3.1 Units and Scales Overview

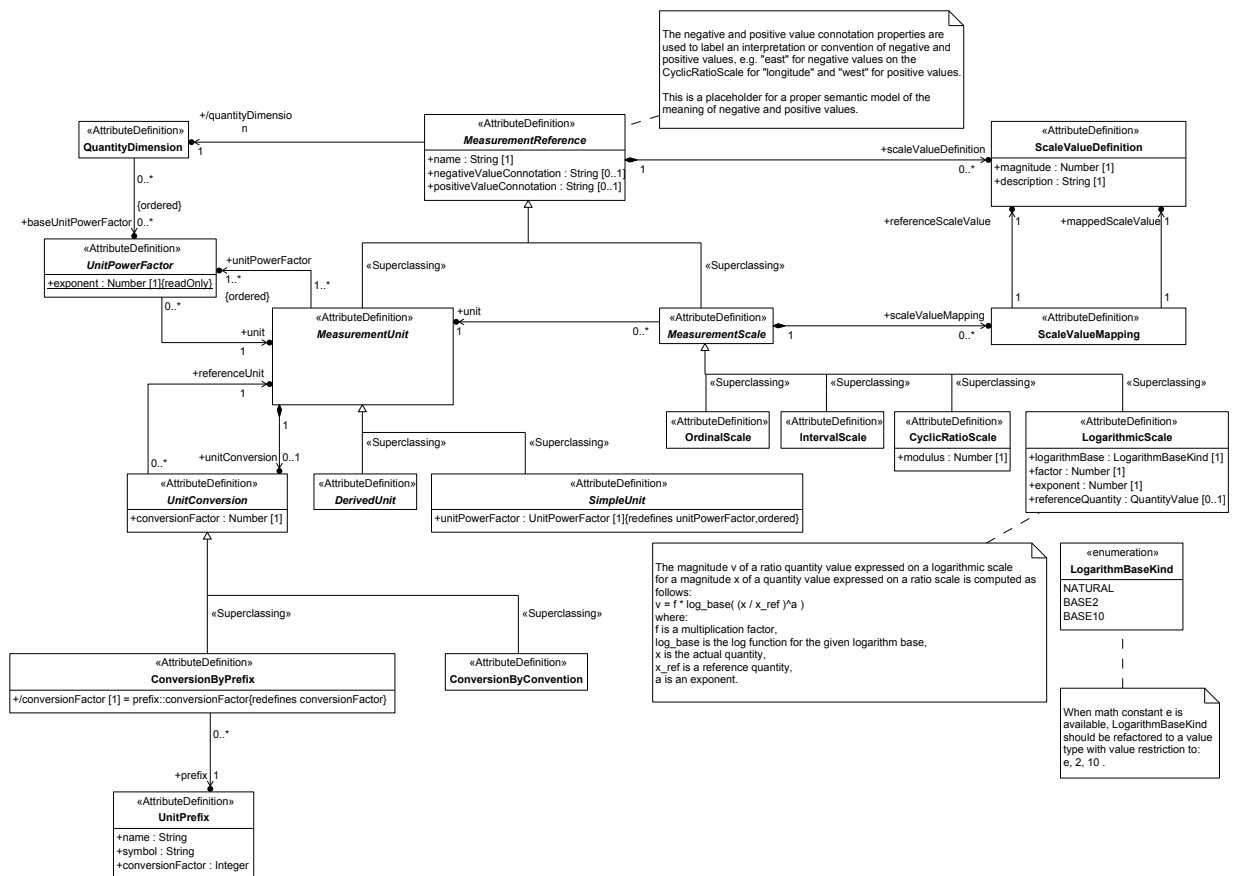


Figure 81. Measurement Units and Scales

8.2.3.2 Elements

8.2.3.2.1 ConversionByConvention <AttributeDefinition>

Description

ConversionByConvention is a UnitConversion that is defined according to some convention.

An example is the conversion relationship between "foot" (the owning MeasurementUnit) and "metre" (the referenceUnit MeasurementUnit), with conversionFactor 3048/10000, since 1 foot = 0.3048 metre, as defined in [NIST SP-811].

General Classes

UnitConversion

Attributes

No attributes.

Constraints

No constraints.

8.2.3.2.2 ConversionByPrefix <AttributeDefinition>

Description

ConversionByPrefix is a UnitConversion that is defined through reference to a named [ISO/IEC 80000-1] UnitPrefix, which represents a conversion factor that is a decimal or binary multiple or sub-multiple.

Example 1: "kilometre" (symbol "km") with the "kilo" UnitPrefix denoting conversion factor 1000 and referenceUnit "metre".

Example 2: "nanofarad" (symbol "nF") with the "nano" UnitPrefix denoting conversion factor 1E-9 and referenceUnit "farad".

Example 3: "mebibyte" (symbol "MiB" or alias "MiByte") with the "mebi" UnitPrefix denoting conversion factor 1024^2 (a binary multiple) and referenceUnit "byte".

General Classes

UnitConversion

Attributes

/conversionFactor {redefines conversionFactor}

Attribute conversionFactor is a Number that is derived from the conversionFactor of the associated prefix UnitPrefix.

prefix : UnitPrefix

Attribute prefix is a UnitPrefix that represents one of the named unit prefixes defined in [ISO/ICE-80000-1] as a decimal or binary multiple or sub-multiple.

Constraints

No constraints.

8.2.3.2.3 CyclicRatioScale <AttributeDefinition>

Description

CyclicRatioScale is a MeasurementScale that represents a ratio scale with a periodic cycle.

Example 1: "cyclic degree" (to express planar angular measures) with modulus 360 and unit "degree".

Example 2: "hour of day" with modulus 24 and unit "hour".

General Classes

MeasurementScale

Attributes

modulus : Number

Attribute `modulus` is a Number that defines the modulus, i.e. periodic cycle, of this `CyclicRatioScale`.

Constraints

No constraints.

8.2.3.2.4 DerivedUnit <AttributeDefinition>

Description

`DerivedUnit` is a `MeasurementUnit` that represents a measurement unit that depends on one or more powers of other measurement units.

General Classes

`MeasurementUnit`

Attributes

No attributes.

Constraints

No constraints.

8.2.3.2.5 IntervalScale <AttributeDefinition>

Description

`IntervalScale` is a `MeasurementScale` that represents a linear interval measurement scale, i.e. a scale on which only intervals between two values are meaningful and not their ratios.

Note: In order to enable quantity value conversion between an interval scale and another measurement scale, the offset (sometimes also called zero shift) between the source and target scale must be known. This offset is indirectly defined through a `ScaleValueMapping`, see `scaleValueMapping` of `MeasurementScale`.

General Classes

`MeasurementScale`

Attributes

No attributes.

Constraints

No constraints.

8.2.3.2.6 LogarithmBaseKind

Description

cf documentation does not exist

General Classes

No general classes.

Literal Values

cf name does not exist

cf documentation does not exist

cf name does not exist

cf documentation does not exist

cf name does not exist

cf documentation does not exist

8.2.3.2.7 LogarithmicScale <AttributeDefinition>

Description

LogarithmicScale is a MeasurementScale that represents a logarithmic measurement scale that is defined as follows. The numeric value v of a ratio quantity expressed on a logarithmic scale equivalent with a value x of the same quantity expressed on a ratio scale (i.e. only using a MeasurementUnit) is computed as follows:

$$v = f * \log_base((x / x_ref)^a)$$

where: f is a multiplication factor, \log_base is the log function for the given logarithm base, x is the actual quantity, x_ref is a reference quantity, a is an exponent.

General Classes

MeasurementScale

Attributes

exponent : Number

Attribute `exponent` is the exponent a in the logarithmic value expression.

factor : Number

Attribute `factor` is the multiplication factor f in the logarithmic value expression.

logarithmBase : LogarithmBaseKind

Attribute `logarithmicBase` is a Number that specifies the logarithmic base.

The `logarithmicBase` is typically 10, 2 or e (for the natural logarithm).

referenceQuantity : QuantityValue [0..1]

Attribute `referenceQuantity` is the reference quantity value (denominator) x_ref in the logarithmic value expression.

Constraints

No constraints.

8.2.3.2.8 MeasurementReference <AttributeDefinition>

Description

A MeasurementReference an AttributeDefinition that represents the [VIM] concept "measurement reference" which is defined as follows: "A reference can be a measurement unit, a measurement procedure, a reference material, or a combination of such." (see <https://jcg.m.bipm.org/vim/en/1.1.html> NOTE 2). It establishes how to interpret the numerical value of a QuantityValue, and establishes its actual quantity dimension.

General Classes

No general classes.

Attributes

name : String

cf documentation does not exist

negativeValueConnotation : String [0..1]

Attribute `negativeValueConnotation` optionally specifies the connotation of negative quantity values for this MeasurementReference.

An example is "east" for positive values on the MeasurementReference (CyclicRatioScale) for "longitude" and "west" for negative values.

positiveValueConnotation : String [0..1]

Attribute `positiveValueConnotation` optionally specifies the connotation of positive quantity values for this MeasurementReference.

An example is "east" for positive values on the MeasurementReference (CyclicRatioScale) for "longitude" and "west" for negative values.

/quantityDimension : QuantityDimension

Attribute `quantityDimension` is derived to represent the QuantityDimension of this MeasurementReference.

scaleValueDefinition : ScaleValueDefinition [0..*]

Attribute `scaleValueDefinition` specifies zero or more ScaleValueDefinition that represent particular essential values on a measurement unit or scale.

Constraints

No constraints.

8.2.3.2.9 MeasurementScale <AttributeDefinition>

Description

MeasurementScale is a MeasurementReference that represents a (non-ratio) measurement scale.

Note: the majority of scalar quantities can be expressed by just using a `MeasurementUnit` directly as its `MeasurementReference`. This implies expression of the `QuantityValue` on a ratio scale. However, for full coverage of all quantity value expressions, additional explicit measurement scales with different semantics are needed, such as ordinal scale, interval scale, cyclic ratio scale and logarithmic scale.

General Classes

`MeasurementReference`

Attributes

`scaleValueMapping` : `ScaleValueMapping` [0..*]

Attribute `scaleValueMapping` represents an optional `ScaleValueMapping` that specifies the relationship between this `MeasurementScale` and another `MeasurementReference` in terms of equivalent `QuantityValues`.

`unit` : `MeasurementUnit`

Attribute `unit` specifies the `MeasurementUnit` that defines an interval of one on this `MeasurementScale`.

Constraints

No constraints.

8.2.3.2.10 `MeasurementUnit` <AttributeDefinition>

Description

A `MeasurementUnit` is a `MeasurementReference` that represents a measurement unit. As defined in [VIM] a measurement unit is a "real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number".

Direct use of a `MeasurementUnit` as the `mRef` attribute of a `QuantityValue`, establishes expressing the `QuantityValue` on a ratio scale.

General Classes

`MeasurementReference`

Attributes

`unitConversion` : `UnitConversion` [0..1]

Attribute `unitConversion` optionally specifies a `UnitConversion` that is a linear conversion factor relationship with another `MeasurementUnit`. This can be used to support automated unit conversion.

`unitPowerFactor` : `UnitPowerFactor` [1..*] {ordered}

Constraints

No constraints.

8.2.3.2.11 `OrdinalScale` <AttributeDefinition>

Description

An `OrdinalScale` is a `MeasurementScale` that represents an ordinal measurement scale, i.e. a scale on which only quantities value ordering is meaningful, not intervals between two values and neither their ratio.

General Classes

`MeasurementScale`

Attributes

No attributes.

Constraints

No constraints.

8.2.3.2.12 QuantityDimension <AttributeDefinition>

Description

A `QuantityDimension` is an `AttributeDefinition` that represents the [VIM] concept quantity dimension, which is a product of powers of the set of base quantities defined for a particular system of quantities and units.

[VIM] defines quantity dimension as "expression of the dependence of a quantity on the base quantities of a system of quantities as a product of powers of factors corresponding to the base quantities, omitting any numerical factor" (see <https://jcgm.bipm.org/vim/en/1.7.html>).

General Classes

No general classes.

Attributes

`baseUnitPowerFactor` : `UnitPowerFactor` [0..*] {ordered}

Attribute `baseUnitPowerFactor` is a `UnitPowerFactor` that specifies a base `MeasurementUnit` and an exponent.

Constraints

No constraints.

8.2.3.2.13 ScaleValueDefinition <AttributeDefinition>

Description

`ScaleValueDefinition` is an `AttributeDefinition` that specifies a particular essential value of a `MeasurementReference`. Typically such a particular value is defined by convention.

Example: For the "kelvin" `MeasurementUnit` / ratio scale for thermodynamic temperature a `ScaleValueDefinition` with `num` is 273.16 and `description` is "absolute temperature of the triple point of pure water") can be specified.

General Classes

No general classes.

Attributes

description : String

magnitude : Number

Constraints

No constraints.

8.2.3.2.14 ScaleValueMapping <AttributeDefinition>

Description

ScaleValueDefinition is an AttributeDefinition that represents the mapping of equivalent quantity values expressed on two different measurement scales.

Example: The mapping between the equivalent thermodynamic temperature quantity values of 273.16 K on the "kelvin" MeasurementUnit ratio scale and 0.01 degree Celsius on the "degree Celsius" IntervalScale would specify a referenceScaleValue being the ScaleValueDefinition with num is 273.16 and description is "absolute thermodynamic temperature of the triple point of water") of the "kelvin" ratio scale, as well as a mappedScaleValue being the ScaleValueDefinition with num is 0.01 and description is "absolute thermodynamic temperature of the triple point of water" of the "degree Celsius" IntervalScale. From this ScaleValueMapping the offset (or zero shift) of 271.15 K between the two scales can be derived.

General Classes

No general classes.

Attributes

mappedScaleValue : ScaleValueDefinition

Attribute mappedScaleValue is a ScaleValueDefinition defined on the owning MeasurementScale that is equivalent to the referenceScaleValue.

referenceScaleValue : ScaleValueDefinition

Attribute referenceScaleValue is a ScaleValueDefinition defined on a reference MeasurementReference.

Constraints

No constraints.

8.2.3.2.15 SimpleUnit <AttributeDefinition>

Description

SimpleUnit is a MeasurementUnit that does not depend on any other measurement unit.

Note: As a consequence the unitPowerFactor of a SimpleUnit references itself with an exponent of one.

General Classes

MeasurementUnit

Attributes

```
unitPowerFactor : UnitPowerFactor {redefines unitPowerFactor, ordered}
```

Constraints

exponentIsOne

[no documentation]

```
this.unitPowerFactor1.exponent == 1
```

ExponentIsOne

[no documentation]

```
self.unitPowerFactor.exponent = 1
```

8.2.3.2.16 UnitConversion <AttributeDefinition>

Description

A UnitConversion is an AttributeDefinition that represents a linear conversion relationship between one measurement unit and another measurement unit, that acts as a reference.

General Classes

No general classes.

Attributes

conversionFactor : Number

Attribute `conversionFactor` is the Number value of the ratio between the quantity expressed in the owning MeasurementUnit over the quantity expressed in the `referenceUnit`.

referenceUnit : MeasurementUnit

Attribute `referenceUnit` establishes the reference MeasurementUnit with respect to which this UnitConversion is defined.

Constraints

No constraints.

8.2.3.2.17 UnitPowerFactor <AttributeDefinition>

Description

A UnitPowerFactor is an AttributeDefinition that represents a power factor of a MeasurementUnit and an exponent.

Note: A collection of UnitPowerFactors defines a unit power product.

General Classes

No general classes.

Attributes

exponent : Number

Attribute `exponent` is a Number that specifies the exponent of this `UnitPowerFactor`.

unit : MeasurementUnit

Attribute `unit` is the MeasurementUnit of this `UnitPowerFactor`.

Constraints

No constraints.

8.2.3.2.18 UnitPrefix <AttributeDefinition>

Description

`UnitPrefix` is an `AttributeDefinition` that represents a named multiple or sub-multiple measurement unit prefix as defined in ISO/IEC 80000-1.

General Classes

No general classes.

Attributes

conversionFactor : Integer

Attribute `conversionFactor` is an Integer that specifies the value of multiple or sub-multiple of this `UnitPrefix`.

name : String

cf documentation does not exist

symbol : String

Attribute `symbol` represents the short symbolic name of this `UnitPrefix`.

Examples are: "k" for "kilo", "m" for "milli", "MeBi" for "mega binary".

Constraints

No constraints.

8.2.4 ISQ

8.2.4.1 ISQ Overview

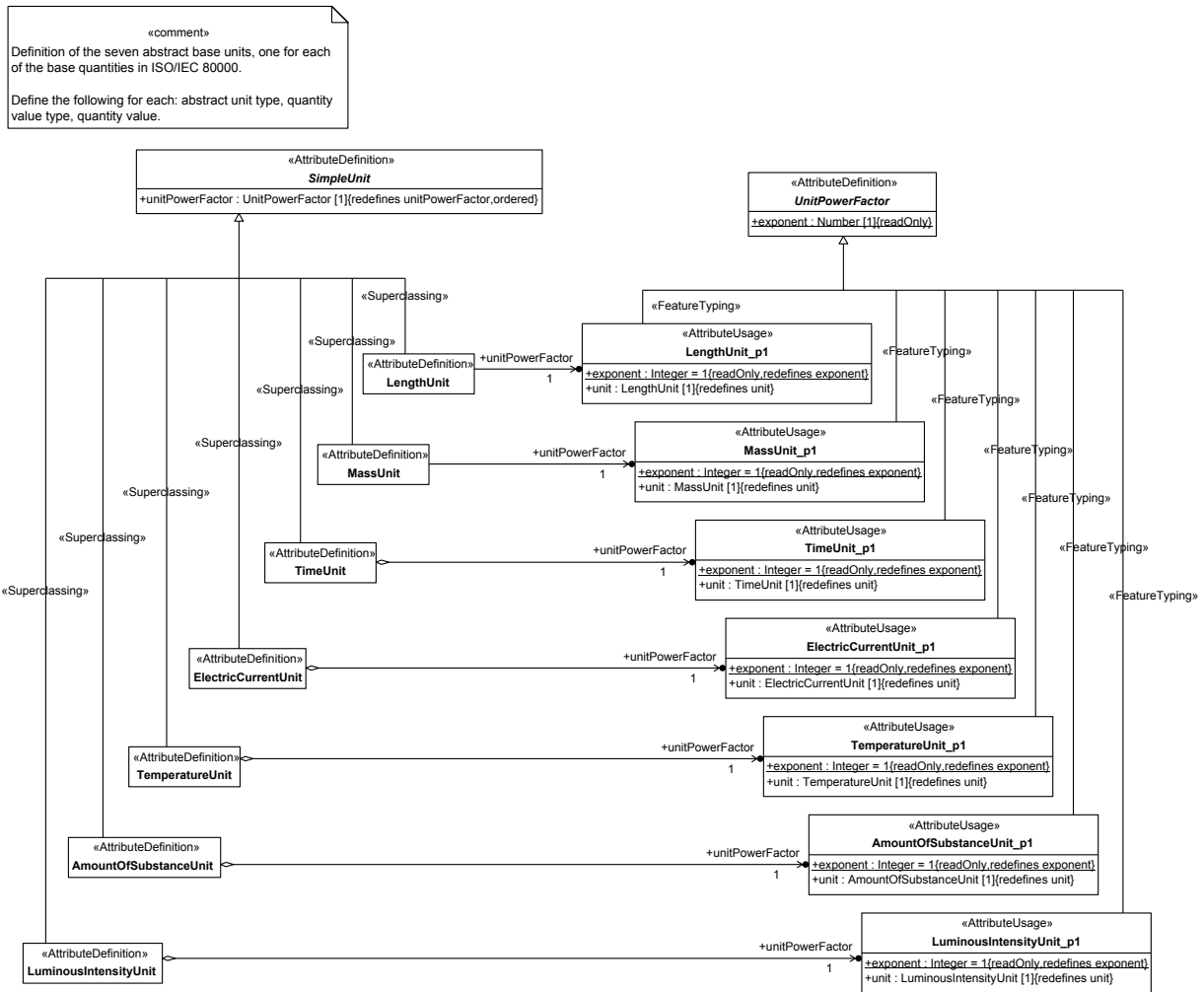


Figure 82. Generic Base Unit Types

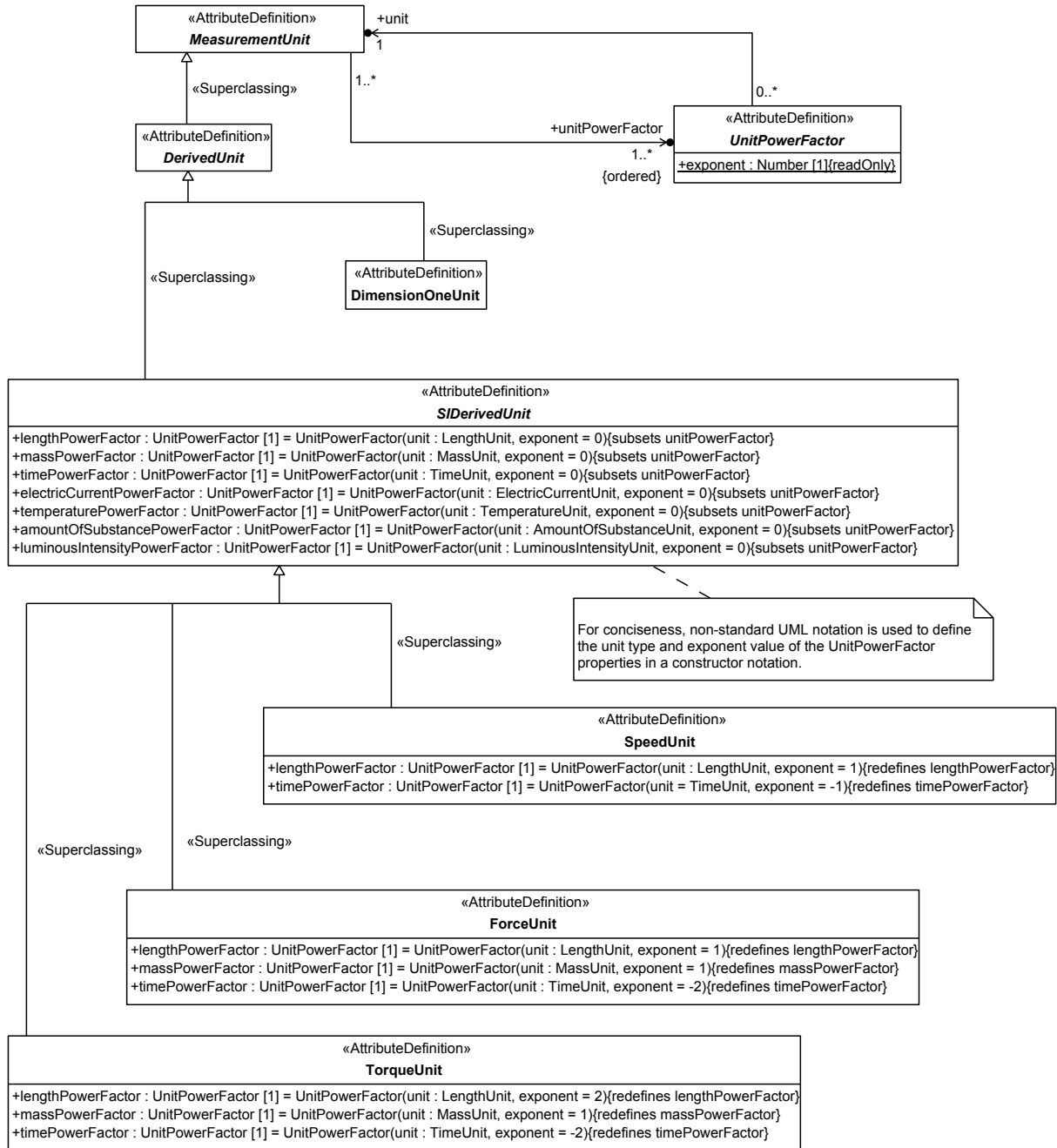


Figure 83. Generic Derived Unit Types

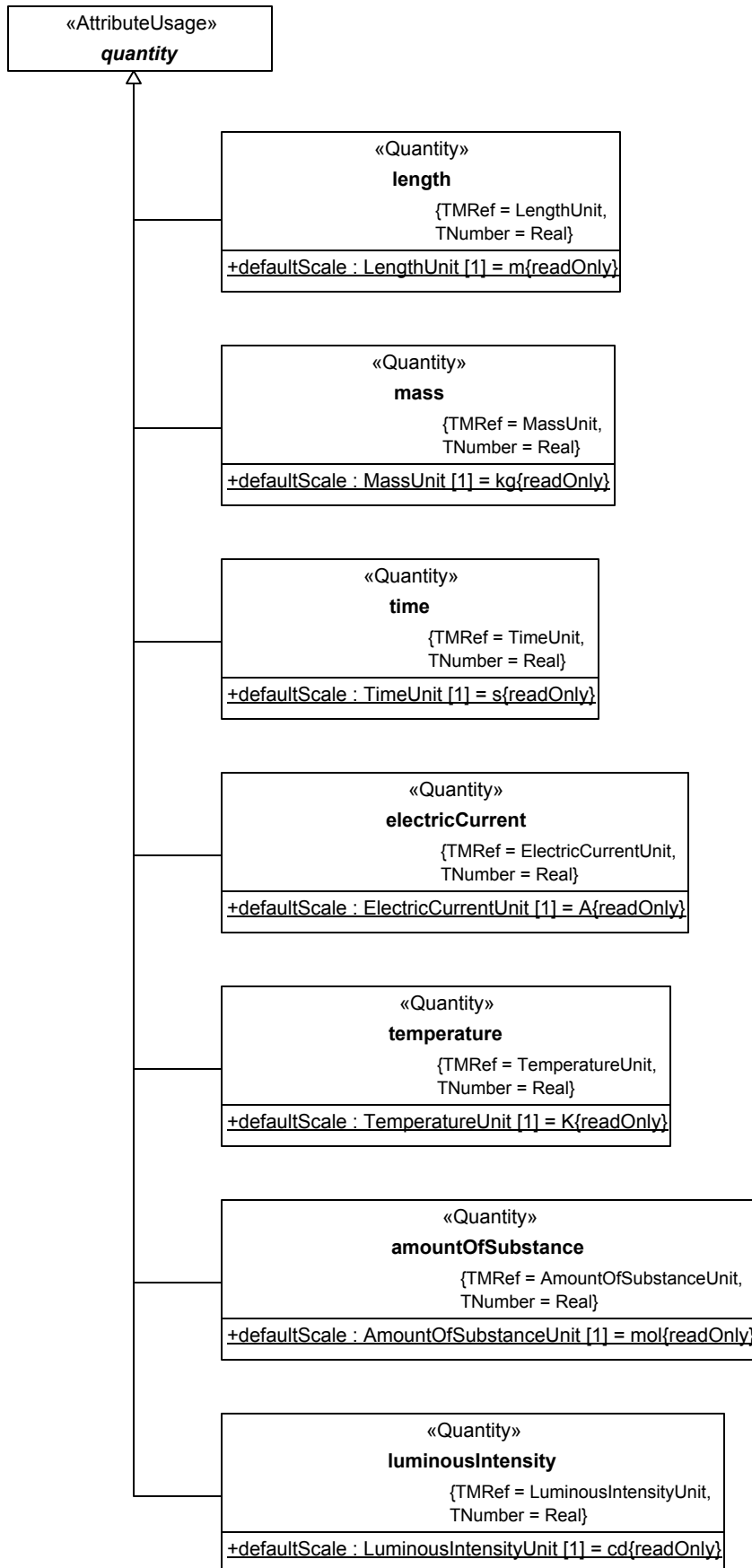


Figure 84. Base Quantities

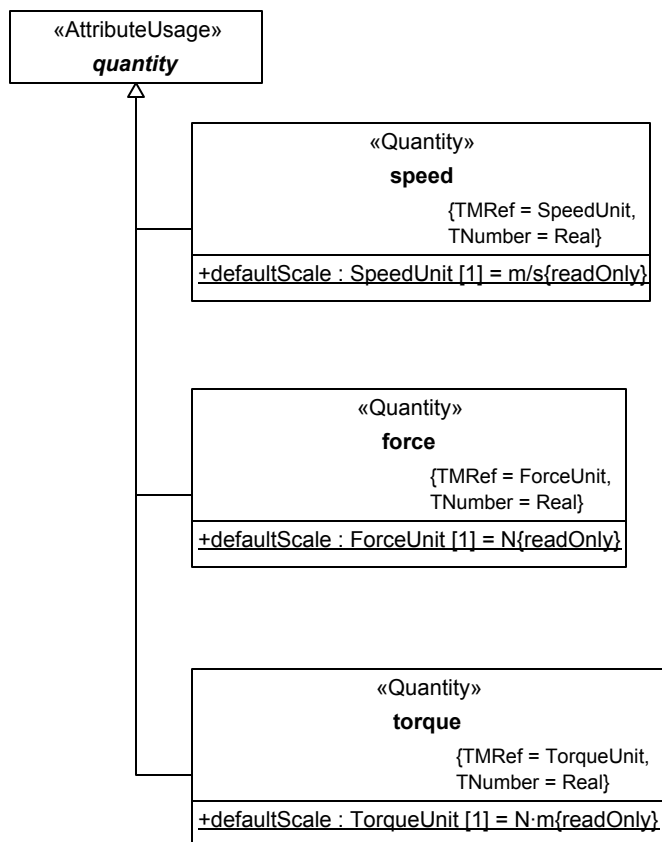


Figure 85. Derived Quantities

8.2.4.2 Elements

8.2.4.2.1 amountOfSubstance

Description

Attributes

defaultScale : AmountOfSubstanceUnit

8.2.4.2.2 AmountOfSubstanceUnit

Description

Attributes

unitPowerFactor : AmountOfSubstanceUnit_p1

8.2.4.2.3 AmountOfSubstanceUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : AmountOfSubstanceUnit {redefines unit}

8.2.4.2.4 DimensionOneUnit

Description

The "unit of dimension one" (sometimes also known as the "dimensionless unit") has been added explicitly for convenience. In its simplest form UnitOfDimensionOne has zero unitPowerFactor which is equivalent to having exponent is zero for any unitPowerFactor. The quantityDimension of a UnitOfDimensionOne is always one.

Attributes

No attributes.

8.2.4.2.5 electricCurrent

Description

Attributes

defaultScale : ElectricCurrentUnit

8.2.4.2.6 ElectricCurrentUnit

Description

Attributes

unitPowerFactor : ElectricCurrentUnit_p1

8.2.4.2.7 ElectricCurrentUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : ElectricCurrentUnit {redefines unit}

8.2.4.2.8 force

Description

Attributes

defaultScale : ForceUnit

8.2.4.2.9 ForceUnit

Description

Attributes

lengthPowerFactor : UnitPowerFactor {redefines lengthPowerFactor}

massPowerFactor : UnitPowerFactor {redefines massPowerFactor}

timePowerFactor : UnitPowerFactor {redefines timePowerFactor}

8.2.4.2.10 ForceUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : ForceUnit {redefines unit}

8.2.4.2.11 length

Description

Attributes

defaultScale : LengthUnit

8.2.4.2.12 LengthUnit

Description

Attributes

unitPowerFactor : LengthUnit_p1

8.2.4.2.13 LengthUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : LengthUnit {redefines unit}

8.2.4.2.14 luminousIntensity

Description

Attributes

defaultScale : LuminousIntensityUnit

8.2.4.2.15 LuminousIntensityUnit

Description

Attributes

unitPowerFactor : LuminousIntensityUnit_p1

8.2.4.2.16 LuminousIntensityUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : LuminousIntensityUnit {redefines unit}

8.2.4.2.17 mass

Description

Attributes

defaultScale : MassUnit

8.2.4.2.18 MassUnit

Description

Attributes

unitPowerFactor : MassUnit_p1

8.2.4.2.19 MassUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : MassUnit {redefines unit}

8.2.4.2.20 quantityOfDimensionOne

Description

Attributes

No attributes.

8.2.4.2.21 SIDerivedUnit

Description

SIDerivedUnit predefines the abstract superclass that references the seven SI base SimpleUnits each with exponent = 0.

Attributes

lengthPowerFactor : UnitPowerFactor {subsets unitPowerFactor}

massPowerFactor : UnitPowerFactor {subsets unitPowerFactor}

timePowerFactor : UnitPowerFactor {subsets unitPowerFactor}

electricCurrentPowerFactor : UnitPowerFactor {subsets unitPowerFactor}

temperaturePowerFactor : UnitPowerFactor {subsets unitPowerFactor}

amountOfSubstancePowerFactor : UnitPowerFactor {subsets unitPowerFactor}

luminousIntensityPowerFactor : UnitPowerFactor {subsets unitPowerFactor}

8.2.4.2.22 speed

Description

Attributes

defaultScale : SpeedUnit

8.2.4.2.23 SpeedUnit

Description

Attributes

lengthPowerFactor : UnitPowerFactor {redefines lengthPowerFactor}

timePowerFactor : UnitPowerFactor {redefines timePowerFactor}

8.2.4.2.24 temperature

Description

Attributes

defaultScale : TemperatureUnit

8.2.4.2.25 TemperatureUnit

Description

Attributes

unitPowerFactor : TemperatureUnit_p1

8.2.4.2.26 TemperatureUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : TemperatureUnit {redefines unit}

8.2.4.2.27 time

Description

Attributes

defaultScale : TimeUnit

8.2.4.2.28 TimeUnit

Description

Attributes

unitPowerFactor : TimeUnit_p1

8.2.4.2.29 TimeUnit_m1

Description

Attributes

exponent : Integer {redefines exponent}

unit : TimeUnit {redefines unit}

8.2.4.2.30 TimeUnit_m2

Description

Attributes

exponent : Integer {redefines exponent}

unit : TimeUnit {redefines unit}

8.2.4.2.31 TimeUnit_p1

Description

Attributes

exponent : Integer {redefines exponent}

unit : TimeUnit {redefines unit}

8.2.4.2.32 torque

Description

Attributes

defaultScale : TorqueUnit

8.2.4.2.33 TorqueUnit

Description

Attributes

lengthPowerFactor : UnitPowerFactor {redefines lengthPowerFactor}
massPowerFactor : UnitPowerFactor {redefines massPowerFactor}
timePowerFactor : UnitPowerFactor {redefines timePowerFactor}

8.2.5 SI Prefixes

8.2.5.1 SI Prefixes Overview

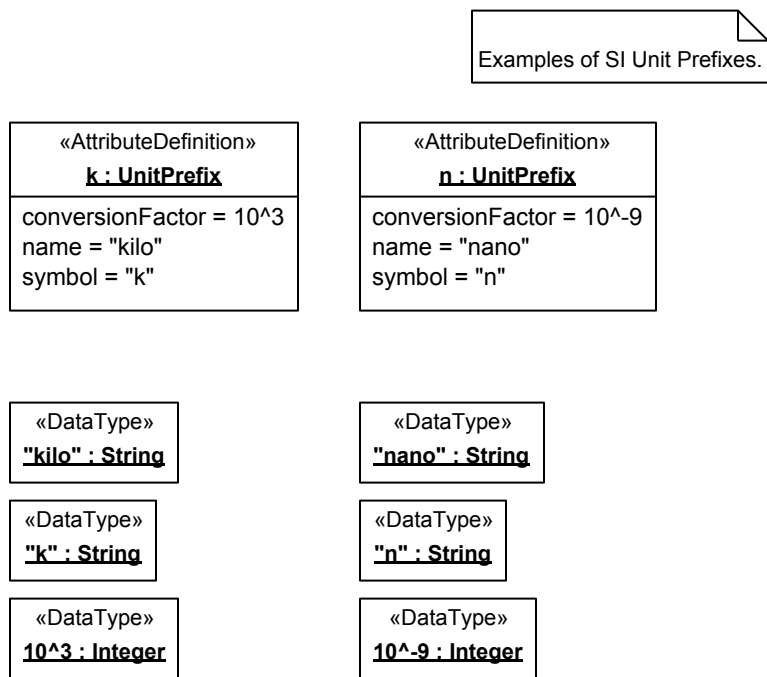


Figure 86. SI Prefixes

8.2.5.2 Elements

8.2.6 SI

8.2.6.1 SI Overview

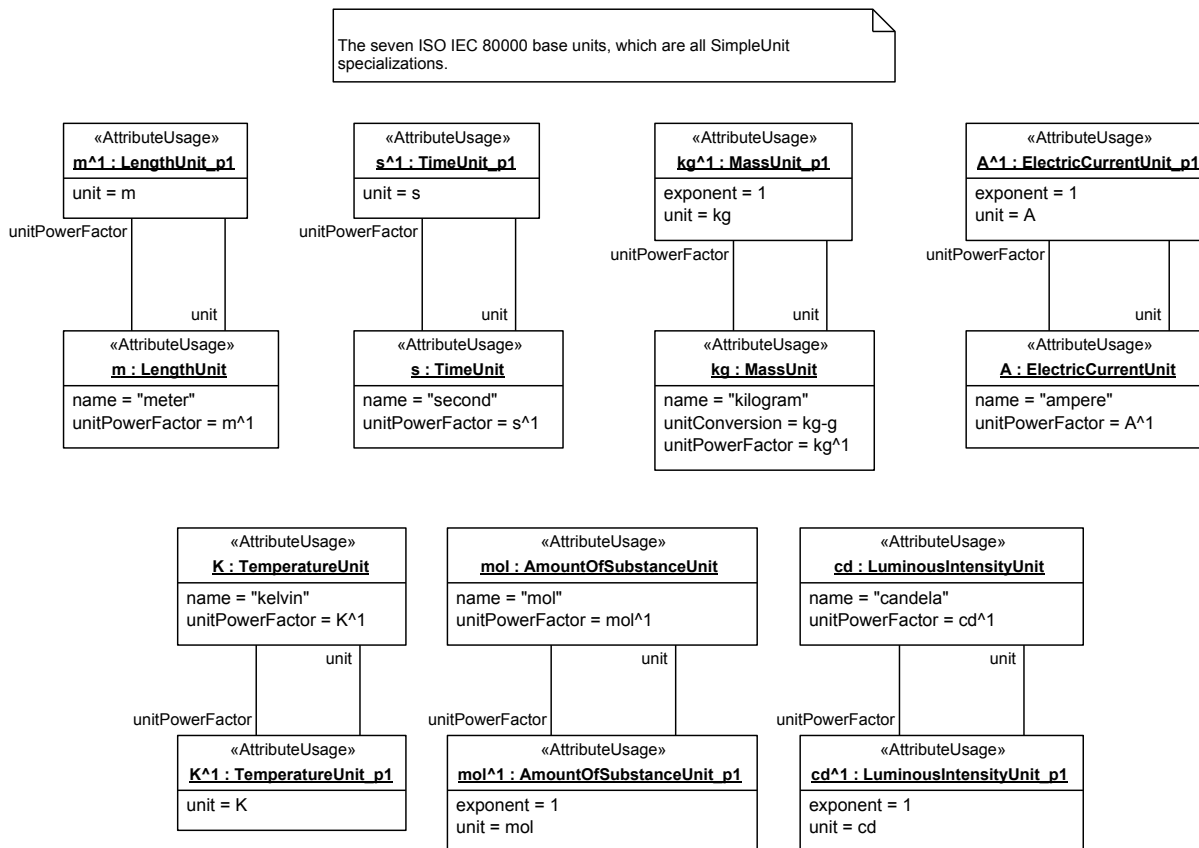


Figure 87. SI Base Units

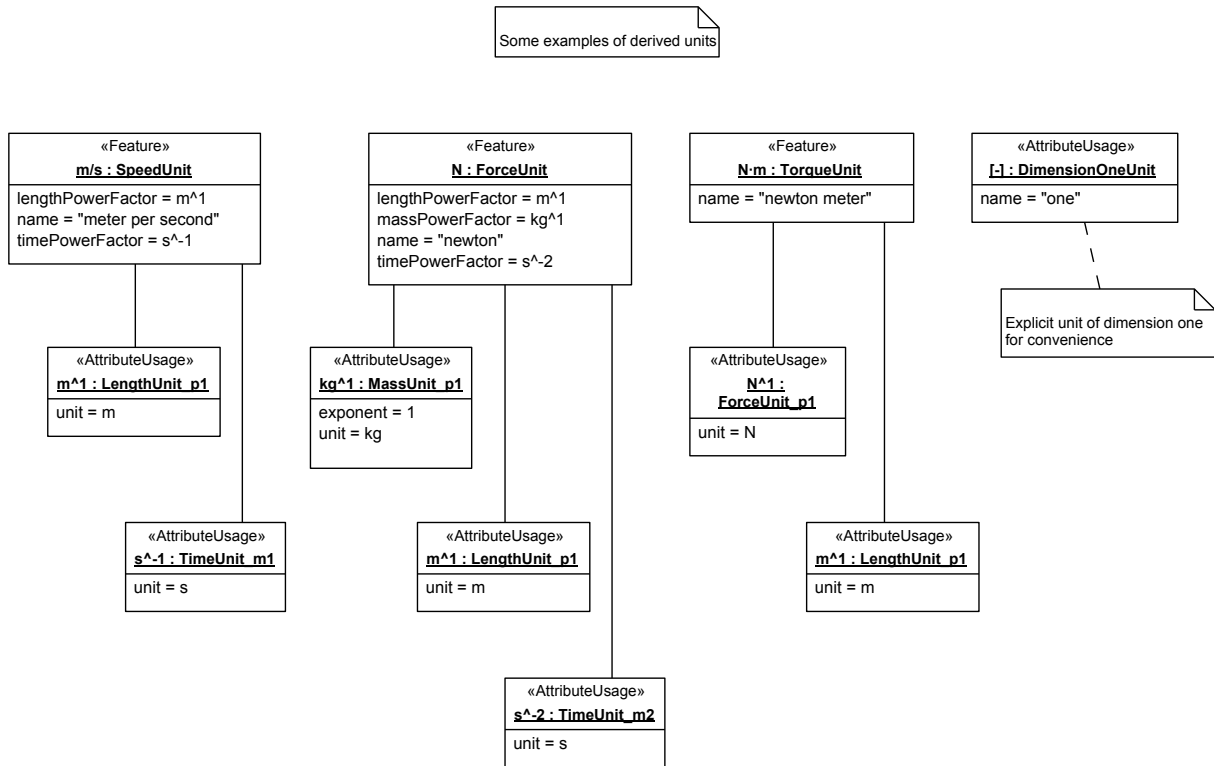


Figure 88. SI Derived Units

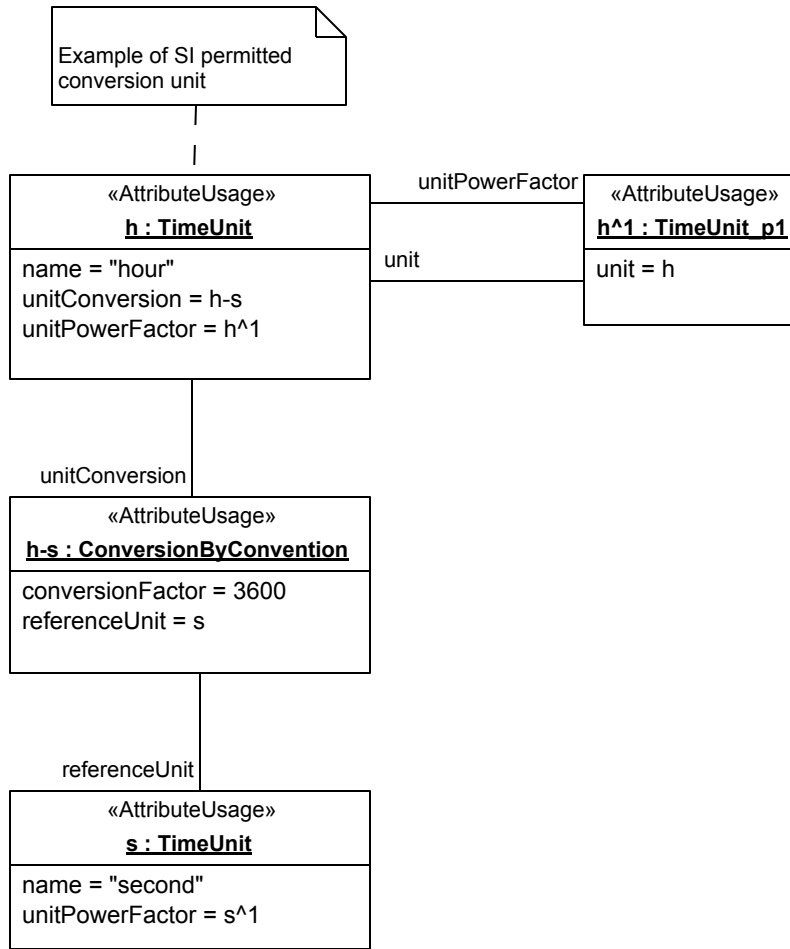


Figure 89. SI Conversion by Convention Units

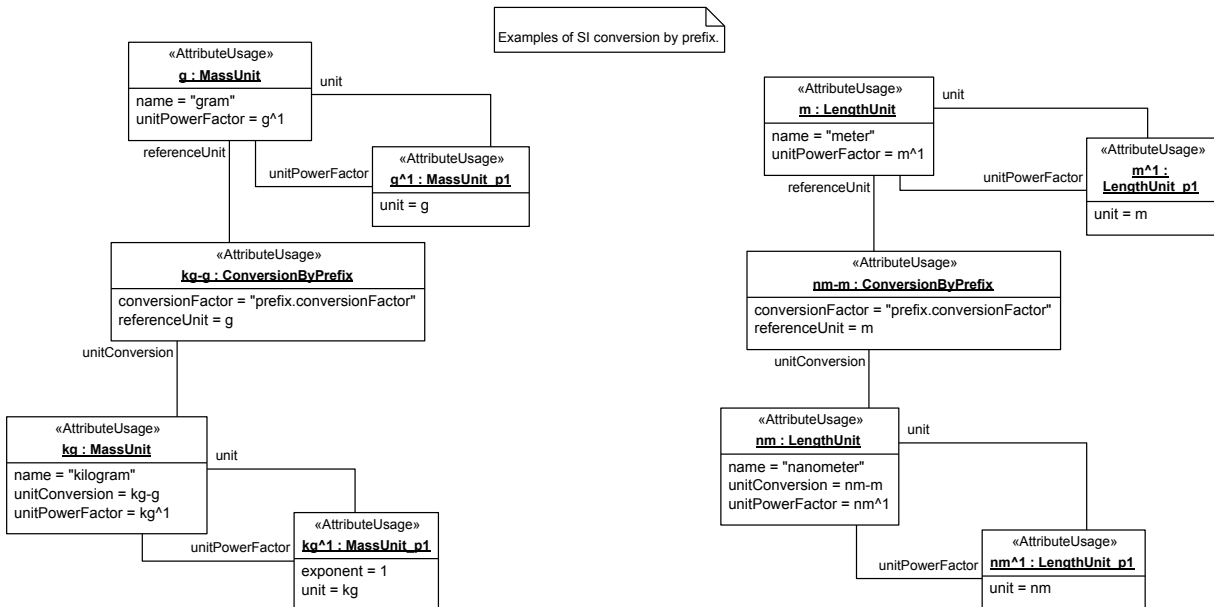


Figure 90. SI Conversion by Prefix Units

8.2.6.2 Elements

8.2.6.2.1 [-]

Description

Attributes

name : String = one

8.2.6.2.2 A

Description

Attributes

unitPowerFactor : ElectricCurrentUnit_p1 = A^1

name : String = ampere

8.2.6.2.3 A^1

Description

Attributes

exponent : Integer = 1

unit : MeasurementUnit = A

8.2.6.2.4 cd

Description

Attributes

name : String = candela

unitPowerFactor : LuminousIntensityUnit_p1 = cd^1

8.2.6.2.5 cd^1

Description

Attributes

unit : MeasurementUnit = cd

exponent : Integer = 1

8.2.6.2.6 g

Description

Attributes

name : String = gram

unitPowerFactor : MassUnit_p1 = g^1

8.2.6.2.7 g^1

Description

Attributes

unit : MeasurementUnit = g

8.2.6.2.8 h

Description

Attributes

unitConversion : UnitConversion = h-s

unitPowerFactor : TimeUnit_p1 = h^1

name : String = hour

8.2.6.2.9 h-s

Description

Attributes

referenceUnit : MeasurementUnit = s

conversionFactor : Number = 3600

8.2.6.2.10 h^1

Description

Attributes

unit : MeasurementUnit = h

8.2.6.2.11 in-m

Description

Attributes

referenceUnit : MeasurementUnit = m

conversionFactor : Number = 254/1000

8.2.6.2.12 K

Description

Attributes

unitPowerFactor : TemperatureUnit_p1 = K¹

name : String = kelvin

8.2.6.2.13 K¹

Description

Attributes

unit : MeasurementUnit = K

8.2.6.2.14 kg

Description

Attributes

name : String = kilogram

unitPowerFactor : MassUnit_p1 = kg¹

unitConversion : UnitConversion = kg-g

8.2.6.2.15 kg-g

Description

Attributes

referenceUnit : MeasurementUnit = g

conversionFactor = prefix.conversionFactor

8.2.6.2.16 kg¹

Description

Attributes

unit : MeasurementUnit = kg

exponent : Integer = 1

8.2.6.2.17 m

Description

Attributes

name : String = meter

unitPowerFactor : LengthUnit_p1 = m¹

8.2.6.2.18 m/s

Description

Attributes

timePowerFactor : UnitPowerFactor = s⁻¹

lengthPowerFactor : UnitPowerFactor = m¹

name : String = meter per second

8.2.6.2.19 m¹

Description

Attributes

unit : MeasurementUnit = m

8.2.6.2.20 mol

Description

Attributes

unitPowerFactor : AmountOfSubstanceUnit_p1 = mol¹

name : String = mol

8.2.6.2.21 mol¹

Description

Attributes

unit : MeasurementUnit = mol

exponent : Integer = 1

8.2.6.2.22 N

Description

Attributes

timePowerFactor : UnitPowerFactor = s⁻²

lengthPowerFactor : UnitPowerFactor = m¹

massPowerFactor : UnitPowerFactor = kg¹

name : String = newton

8.2.6.2.23 N¹

Description

Attributes

unit : ForceUnit = N

8.2.6.2.24 nm

Description

Attributes

name : String = nanometer

unitPowerFactor : LengthUnit_p1 = nm¹

unitConversion : UnitConversion = nm-m

8.2.6.2.25 nm-m

Description

Attributes

conversionFactor = prefix.conversionFactor

referenceUnit : MeasurementUnit = m

8.2.6.2.26 nm¹

Description

Attributes

unit : MeasurementUnit = nm

8.2.6.2.27 N·m

Description

Attributes

name : String = newton meter

8.2.6.2.28 s

Description

Attributes

name : String = second

unitPowerFactor : TimeUnit_p1 = s¹

8.2.6.2.29 s⁻¹

Description

Attributes

unit : TimeUnit = s

8.2.6.2.30 s⁻²

Description

Attributes

unit : TimeUnit = s

8.2.6.2.31 s¹

Description

Attributes

unit : MeasurementUnit = s

8.2.7 US Customary Units

8.2.7.1 US Customary Units Overview

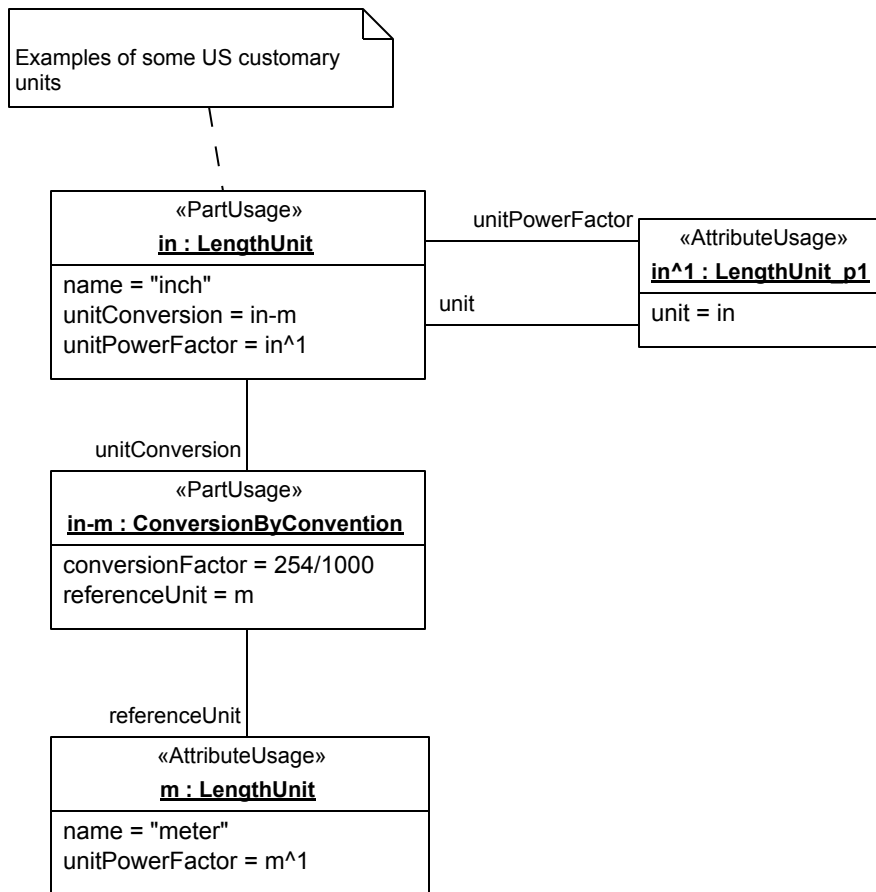


Figure 91. US Customary Units

8.2.7.2 Elements

8.2.7.2.1 in

Description

Attributes

unitPowerFactor : LengthUnit_p1 = in^1

name : String = inch

unitConversion : UnitConversion = in-m

8.2.7.2.2 in^1

Description

Attributes

unit : MeasurementUnit = in

8.2.8 Date and Time

8.2.8.1 Date and Time Overview

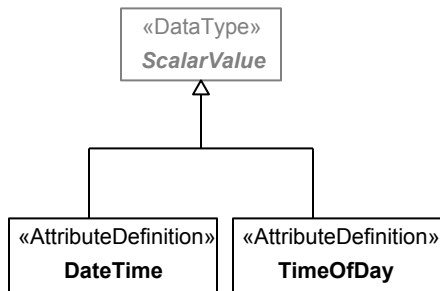


Figure 92. Calendar Dates and Times

8.2.8.2 Elements

8.2.8.2.1 DateTime

Description

Special type to represent ISO 8601 date-time as a convenience because it is so pervasive. Conversion functions can be created that convert ISO 8601 date-time to and from time instants defined using quantities, units and scales, i.e. time instants expressed on a an IntervalScale that defines the (proleptic) Gregorian Calendar.

Attributes

No attributes.

8.2.8.2.2 TimeOfDay

Description

ISO 8601 time instant within an ISO 8601 24 hour day.

Attributes

No attributes.

A Annex: Conformance Test Suite

Submission Note. A conformance test suite will be provided in the revised submission.

B Annex: Example Model

Release Note. The following example is provided as a sample of the SysML textual notation as it has been defined so far. A graphical representation will be provided in a future release.

```
package VehicleModel {
  import Definitions::*;
  package Definitions{
    // These imports eliminate the need to import into each nested package
    import PartDefinitions::*;
    import PortDefinitions::*;
    import ItemDefinitions::*;
    import SignalDefinitions::*;
    import InterfaceDefinitions::*;
    import ActionDefinitions::*;
    import StateDefinitions::*;
    import RequirementDefinitions::*;
    import AttributeDefinitions::*;
    import IndividualDefinitions::*;
    package PartDefinitions{
      part def Vehicle {
        attribute mass :> ISQ::mass;
        attribute dryMass:>ISQ::mass;
        attribute cargoMass:>ISQ::mass;
        attribute position:>ISQ::length;
        attribute velocity:>ISQ::speed;
        attribute acceleration:>ISQ::acceleration;
        attribute electricalPower:>ISQ::power;
        attribute Tmax:>ISQ::temperature;
        attribute maintenanceTime: Time::DateTime;
        attribute brakePedalDepressed: Boolean;
        port fuelCmdPort:FuelCmdPort;
        port vehicleToRoadPort:VehicleToRoadPort;
        perform action providePower;
        perform action performSelfTest;
        perform action applyParkingBrake;
        perform action senseTemperature;
        exhibit state vehicleStates;
      }
      part def Engine;
      part def Cylinder;
      part def Transmission;
      part def Driveshaft;
      part def AxleAssembly;
      part def Axle{
        attribute mass:>ISQ::mass;
      }
      part def FrontAxle:>Axle{
        attribute steeringAngle:ScalarValues::Real;
      }
      part def HalfAxle;
      part def Differential;
      part def Wheel {
```

```

        attribute diameter:LengthValue;
    }
    abstract part def Software;
    part def VehicleSoftware:>Software;
    part def VehicleController:>Software {
        exhibit state controllerStates: ControllerStates;
    }
    part def FuelTank{
        attribute mass :> ISQ::mass;
        ref item fuel:Fuel{
            attribute redefines fuelMass;
        }
        attribute fuelMassMax:>ISQ::mass;
        assert constraint {fuel::fuelMass<=fuelMassMax}
    }
    part def Road{
        attribute incline:Real;
        attribute friction:Real;
    }
    part def VehicleRoadContext{
        attribute time:TimeValue;
    }

    // Used for Specifying Context for Individuals
    part def SpatialTemporalReference;

    // Used for Defining Variants for Superset Model
    part def Engine4Cyl;
    part def Engine6Cyl;
    part def TransmissionChoices;
    part def TransmissionAutomatic;
    part def TransmissionManual;
    part def Sunroof;

}
package PortDefinitions{
    port def FuelCmdPort{
        in item fuelCmd:FuelCmd;
    }
    port def DrivePwrPort{
        out engineTorque:Torque;
    }
    port def ClutchPort;
    port def ShaftPort_a;
    port def ShaftPort_b;
    port def ShaftPort_c;
    port def ShaftPort_d;
    port def DiffPort;
    port def AxlePort;
    port def AxleToWheelPort;
    port def WheelToAxlePort;
    port def WheelToRoadPort;
    port def VehicleToRoadPort;
}

```



```

package ItemDefinitions{
    item def Fuel{
        attribute fuelMass:>ISQ::mass;
    }
    item def FuelCmd;
}
package SignalDefinitions{
    attribute def VehicleStartSignal;
    attribute def VehicleOnSignal;
    attribute def VehicleOffSignal;
    attribute def StartSignal;
    attribute def OffSignal;
    attribute def OverTemp;
    attribute def ReturnToNormal;

    // The following are work arounds until time events and
    // change events are available
    attribute def 'at(vehicle::maintenanceTime)';
    attribute def 'when(temp>vehicle::Tmax)';
}
package InterfaceDefinitions{
    interface def EngineToTransmissionInterface{
        end p1:DrivePwrPort;
        end p2:ClutchPort;
    }
}
package ActionDefinitions{
    action def ProvidePower {
        in item fuelCmd:FuelCmd;
        out wheelToRoadTorque:Torque[2];
    }
    action def GenerateTorque {
        in item fuelCmd:FuelCmd;
        out engineTorque:Torque;
    }
    action def AmplifyTorque {
        in engineTorque:Torque;
        out transmissionTorque:Torque;
    }
    action def TransferTorque {
        in transmissionTorque:Torque;
        out driveshaftTorque:Torque;
    }
    action def DistributeTorque {
        in driveshaftTorque:Torque;
        out wheelToRoadTorque:Torque[2];
    }
    action def PerformSelfTest;
    action def ApplyParkingBrake;
    action def SenseTemperature{
        out temp: ISQ::TemperatureValue;
    }
}
package StateDefinitions {

```

```

state def VehicleStates;
state def ControllerStates;
}
package RequirementDefinitions{
  requirement def MassRequirement{
    doc /*The actual mass shall be less than the required mass*/
    attribute massRequired:>ISQ::mass;
    attribute massActual:>ISQ::mass;
    require constraint {massActual<=massRequired}
  }
  requirement def ReliabilityRequirement{
    doc /*The actual reliability shall be greater than the required reliabilit
    attribute reliabilityRequired:Real;
    attribute reliabilityActual:Real;
    require constraint {reliabilityActual>=reliabilityRequired}
  }
  requirement def TorqueGenerationRequirement {
    subject engine:Engine;
    doc /* The engine shall generate torque as a function of RPM as shown in
      * Table 1.*/
  }
  requirement def DrivePowerInterfaceRequirement {
    subject engine:Engine;
    doc /* The engine shall transfer its generated torque to the transmission
      * the clutch interface.*/
  }
  requirement def FuelEconomyRequirement {
    doc /* The vehicle shall maintain an average fuel economy of at least
      * x miles per gallon for the nominal driving scenario */
    attribute actualFuelEconomy : DistancePerVolumeValue;
    attribute requiredFuelEconomy : DistancePerVolumeValue;
    require constraint {actualFuelEconomy >= requiredFuelEconomy}
  }
}
package AttributeDefinitions{
  import ScalarValues::*;
  // Scalar Functions provides Sum expression
  import ScalarFunctions::*;
  import ISQ::*;
  import SI::*;
  alias ISQ::TorqueValue as Torque;

  //quantity used in analysis
  attribute def DistancePerVolumeValue:>Quantities::QuantityValue;
}
package IndividualDefinitions{
  individual def SpatialTemporalReference_1:>SpatialTemporalReference;
  individual def VehicleRoadContext_1:>VehicleRoadContext;
  individual def Vehicle_1:>Vehicle;
  individual def FrontAxleAssembly_1:>AxleAssembly;
  individual def FrontAxle_1:>FrontAxle;
  individual def Wheel_1:>Wheel;
  individual def Wheel_2:>Wheel;
}

```

```

        individual def RearAxleAssembly_1:>AxleAssembly;
        individual def Road_1:>Road;
    }
}
package VehicleConfigurations{
    package VehicleConfiguration_a{
        package PartsTree{
            part vehicle_a:Vehicle{
                attribute mass redefines Vehicle::mass=
                    dryMass+cargoMass+fuelTank::fuel::fuelMass;
                attribute dryMass redefines Vehicle::dryMass=sum(partMasses);
                attribute redefines Vehicle::cargoMass=0;
                attribute partMasses=
                    {fuelTank::mass,frontAxleAssembly::mass,rearAxleAssembly::mass};
            part fuelTank:FuelTank{
                attribute redefines mass=75@[kg];
                ref item redefines fuel{
                    attribute redefines fuelMass=50@[kg];
                }
            }
            part frontAxleAssembly:AxleAssembly{
                attribute mass :> ISQ::mass=800@[kg];
                part frontAxle:Axle;
                part frontWheels:Wheel[2];
            }
            part rearAxleAssembly:AxleAssembly{
                attribute mass :> ISQ::mass=875@[kg];
                attribute driveTrainEfficiency:Real = 0.6;
                part rearAxle:Axle;
                part rearWheels:Wheel[2]{
                    attribute redefines diameter;
                }
            }
        }
    }
}
package ActionTree{
}
}
package VehicleConfiguration_b{
    package PartsTree{
        part vehicle_b : Vehicle{
            attribute mass redefines Vehicle::mass=
                dryMass+cargoMass+fuelTank::fuel::fuelMass;
            attribute dryMass redefines Vehicle::dryMass=sum(partMasses);
            attribute redefines Vehicle::cargoMass=0;
            attribute partMasses=
                {fuelTank::mass,frontAxleAssembly::mass,rearAxleAssembly::mass,
                    engine::mass,transmission::mass,driveshaft::mass};
            port redefines fuelCmdPort {
                in item redefines fuelCmd;
            }
            port vehicleToRoadPort redefines vehicleToRoadPort{
                port wheelToRoadPort1:WheelToRoadPort;
            }
        }
    }
}

```

```

    port wheelToRoadPort2:WheelToRoadPort;
  }
perform ActionTree::providePower redefines providePower;
perform ActionTree::performSelfTest redefines performSelfTest;
perform ActionTree::applyParkingBrake redefines applyParkingBrake;
perform ActionTree::senseTemperature redefines senseTemperature;
exhibit States::vehicleStates redefines vehicleStates {
  ref vehicle redefines vehicle = vehicle_b;
}
}
part fuelTank:FuelTank{
  attribute redefines mass=75@[kg];
  ref item redefines fuel{
    attribute redefines fuelMass=60@[kg];
  }
  attribute redefines fuelMassMax=60;
}
part frontAxleAssembly:AxleAssembly{
  attribute mass :> ISQ::mass=800@[kg];
  port shaftPort_d:ShaftPort_d;
  part frontAxle:FrontAxle;
  part frontWheels:Wheel[2];
}
part rearAxleAssembly:AxleAssembly{
  attribute mass :> ISQ::mass=875@[kg];
  attribute driveTrainEfficiency:Real = 0.6;
  port shaftPort_d:ShaftPort_d;
  perform ActionTree::providePower::distributeTorque;
  part rearWheel1:Wheel{
    attribute redefines diameter;
    port wheelToAxlePort:WheelToAxlePort;
    port wheelToRoadPort:WheelToRoadPort;
  }
  part rearWheel2:Wheel{
    attribute redefines diameter;
    port wheelToRoadPort:WheelToRoadPort;
    port wheelToAxlePort:WheelToAxlePort;
  }
  part differential:Differential{
    port shaftPort_d:ShaftPort_d;
    port leftDiffPort:DiffPort;
    port rightDiffPort:DiffPort;
  }
  part rearAxle{
    part leftHalfAxle:HalfAxle{
      port leftAxleToDiffPort:AxlePort;
      port leftAxleToWheelPort:AxlePort;
    }
    part rightHalfAxle:HalfAxle{
      port rightAxleToDiffPort:AxlePort;
      port rightAxleToWheelPort:AxlePort;
    }
  }
}

bind shaftPort_d=differential::shaftPort_d;

```

```

        connect differential::leftDiffPort
            to rearAxle::leftHalfAxle::leftAxleToDiffPort;
        connect differential::rightDiffPort
            to rearAxle::rightHalfAxle::rightAxleToDiffPort;
    }
    part engine:Engine{
        attribute mass :> ISQ::mass=200@[kg];
        attribute peakHorsePower:PowerValue = 200;
        port fuelCmdPort:FuelCmdPort{
            in item redefines fuelCmd;
        }
        port drivePwrPort:DrivePwrPort{
            out redefines engineTorque;
        }
        perform ActionTree::providePower::generateTorque;
        part cylinders:Cylinder[4..6];
    }
    part transmission:Transmission{
        attribute mass :> ISQ::mass=100@[kg];
        //conjugate notation ~
        port clutchPort:~DrivePwrPort;
        port shaftPort_a:ShaftPort_a;
        perform ActionTree::providePower::amplifyTorque;
    }
    part driveshaft:Driveshaft{
        attribute mass :> ISQ::mass=100@[kg];
        port shaftPort_b:ShaftPort_b;
        port shaftPort_c:ShaftPort_c;
        perform ActionTree::providePower::transferTorque;
    }
    part vehicleSoftware:VehicleSoftware{
        part vehicleController: VehicleController {
            exhibit States::controllerStates redefines controllerStates{
                ref controller = vehicleController;
            }
        }
    }

    bind engine::fuelCmdPort=fuelCmdPort;
    interface engineToTransmissionInterface:EngineToTransmissionInterface
        connect engine::drivePwrPort to transmission::clutchPort{
            ref action generateToAmplify :> ActionTree::providePower::gene
        }
    connect transmission::shaftPort_a to driveshaft::shaftPort_b;
    connect driveshaft::shaftPort_c to rearAxleAssembly::shaftPort_d;
    bind rearAxleAssembly::rearWheel1::wheelToRoadPort=vehicleToRoadPort::
    bind rearAxleAssembly::rearWheel2::wheelToRoadPort=vehicleToRoadPort::

    }
}

package ActionTree{
    action providePower:ProvidePower{
        in item redefines fuelCmd;
        out wheelToRoadTorque redefines wheelToRoadTorque [2] =
            distributeTorque::wheelToRoadTorque;
    }
}

```

```

// No successions (control flows) between these actions, because the
// flows between them are continuous streams.
action generateTorque:GenerateTorque {
    in item = providePower::fuelCmd;
    out engineTorque redefines engineTorque;
}
action amplifyTorque:AmplifyTorque {
    in engineTorque redefines engineTorque;
    out transmissionTorque redefines transmissionTorque;
}
action transferTorque:TransferTorque {
    // This is a shorthand for the stream commented out below.
    in transmissionTorque redefines transmissionTorque;
    out driveshaftTorque redefines driveshaftTorque;
}
action distributeTorque:DistributeTorque{
    in driveshaftTorque redefines driveshaftTorque;
    out wheelToRoadTorque redefines wheelToRoadTorque [2];
}

stream generateToAmplify from generateTorque::engineTorque
    to amplifyTorque::engineTorque;
stream amplifyTorque::transmissionTorque
    to transferTorque::transmissionTorque;
stream transferTorque::driveshaftTorque
    to distributeTorque::driveshaftTorque;
}
action performSelfTest: PerformSelfTest;
action applyParkingBrake: ApplyParkingBrake;
action senseTemperature: SenseTemperature;
}
package States{
    state vehicleStates: VehicleStates {
        ref vehicle : Vehicle;
        ref controller : VehicleController;

        state operatingStates {
            entry action initial;

            state off;
            state starting;
            state on {
                entry vehicle::performSelfTest;
                // was vehicle::providePower;
                do ActionTree::providePower;
                exit vehicle::applyParkingBrake;
                constraint {vehicle::electricalPower<=500}
            }

            transition initial then off;

            transition 'off-starting'
                first off

```

```

        accept VehicleStartSignal
        if vehicle::brakePedalDepressed
        do send StartSignal() to controller
        then starting;

    transition 'starting-on'
        first starting
        accept VehicleOnSignal
        then on;

    transition 'on-off'
        first on
        accept VehicleOffSignal
        then off;
}

state healthStates {
    entry action initial;
    do vehicle::senseTemperature (out temp);

    state normal;
    state maintenance;
    state degraded;

    transition initial then normal;

    transition 'normal-maintenance'
        first normal
        accept 'at(vehicle::maintenanceTime)'
        then maintenance;

    transition 'normal-degraded'
        first normal
        accept 'when(temp>vehicle::Tmax)'
        do send OverTemp() to controller
        then degraded;

    transition 'maintenance-normal'
        first maintenance
        accept ReturnToNormal
        then normal;

    transition 'degraded-normal'
        first degraded
        accept ReturnToNormal
        then normal;
}

state controllerStates: ControllerStates {
    state operatingStates {
        entry action initial;
        state off;
        state on;

```

```

        transition initial then off;
        transition 'off-on'
            first off
            //why not a usage of StartSignal?
            accept StartSignal
            then on;
        transition 'on-off'
            first on
            accept OffSignal
            then off;
    }
}

package Requirements{
    import Definitions::PartDefinitions::*;
    import VehicleConfiguration_b::*;
    import VehicleConfiguration_b::PartsTree::*;
    import vehicle_b_SpecificationContext::*;
    item marketSurvey;
    dependency from vehicleSpecification to marketSurvey;
    part vehicle_b_SpecificationContext{
        // The subject of the specification is vehicle:Vehicle, which is a
        // usage of the black box specification. Other vehicles are further
        // specializations of this black box specification.
        // Redefine vehicle_b within the vehicle_b_Specification Context so
        // satisfies can be added.
        part redefines vehicle_b;
        requirement vehicleSpecification{
            subject vehicle:Vehicle;
            requirement id '1' vehicleMassRequirement: MassRequirement {
                doc /* The total mass of a vehicle shall be less than or equal
                    * to the required mass.*/
                /* Assume total mass includes a full tank of gas*/
                attribute redefines massRequired=2000;
                attribute redefines massActual = vehicle::mass;
            }
            requirement id '2' vehicleFuelEconomyRequirements{
                doc /* fuel economy requirements group */
                attribute assumedCargoMass:>ISQ::mass;
                requirement id '2_1' cityFuelEconomyRequirement:
                    FuelEconomyRequirement{
                        redefines requiredFuelEconomy=25; //@[mpg];
                        assume constraint {assumedCargoMass>=500 @[kg]}
                    }
                requirement id '2_2' highwayFuelEconomyRequirement:
                    FuelEconomyRequirement{
                        redefines requiredFuelEconomy=30; //@[mpg]
                        attribute assumedCargoMass:>ISQ::mass;
                        assume constraint {assumedCargoMass>=500 @[kg]}
                    }
            }
        }
    }
    satisfy vehicleSpecification::vehicleMassRequirement
        by vehicle_b;
}

```



```

        satisfy vehicleSpecification::vehicleFuelEconomyRequirements
            by vehicle_b;
        //this should not pass the requirement since vehicle_b::mass=2010
        //and the massRequired=2000

        requirement engineSpecification {
            doc /* Engine power requirements group */
            subject engine: Engine;

            requirement torqueGeneration : TorqueGenerationRequirement;

            requirement drivePowerInterface : DrivePowerInterfaceRequirement;
        }
        satisfy engineSpecification::torqueGeneration by vehicle_b::engine;
    }
}

package VehicleAnalysis{
    import Definitions::AttributeDefinitions::*;
    // the following is a general vehicle dynamics analysis model that is not bound to
    package DynamicsEquations{
        attribute p:PowerValue; // engine power
        attribute m:MassValue;
        attribute v:SpeedValue;
        attribute a:AccelerationValue;

        attribute dt:TimeValue;
        attribute x0:LengthValue;
        attribute x_f:LengthValue;
        attribute v0:SpeedValue;
        attribute v_f:SpeedValue;

        constraint def StraightLineDynamicsEquations{
            attribute v_avg:SpeedValue = (v0 + v_f)/2;
            a == p/(m*v) &
            v_f == v0 +a*dt &
            x_f == x0+v*dt
        }
    }
}

package FuelEconomyAnalysisModel{
    import VehicleConfigurations::VehicleConfiguration_b::PartsTree::*;
    import VehicleConfigurations::VehicleConfiguration_b::Requirements::*;
    import NonScalarValues::SampledFunctionValue;

    attribute def NominalScenario :> SampledFunctionValue;

    analysis fuelEconomyAnalysis {
        return attribute calculatedFuelEconomy:DistancePerVolumeValue;
        in attribute scenario: NominalScenario;
        subject = vehicle_b;

        objective fuelEconomyAnalysisObjective {
            doc /* the objective of this analysis is to determine whether

```

```

        * the vehicle design configuration can
        * satisfy the fuel economy requirements */
require vehicleSpecification::vehicleFuelEconomyRequirements;
}

action straightLineDynamics {
    in power : PowerValue=vehicle_b::engine::peakHorsePower;
    in mass : MassValue=vehicle_b::mass;
    in delta_t : TimeValue;
    in x_in : LengthValue;
    in v_in : SpeedValue;
    out x_out : LengthValue;
    out v_out : SpeedValue;
    out a_out : AccelerationValue;

    assert constraint dynamics {
        attribute v_avg:SpeedValue = (v_in + v_out)/2;
        a_out == power/(mass*v_avg) &
        v_out == v_in +a_out*delta_t &
        x_out == x_in+v_avg*delta_t
    }
}

// perform the fuel consumption analysis based on the outputs from
// the dynamics analysis (e.g., power vs time)

action fuelConsumptionAnalysis {
}

}

package ElectricalPowerAnalysis{
}

package ReliabilityAnalysis{
}

}

package VehicleVerification{
    import Definitions::AttributeDefinitions::*;
    import VehicleConfigurations::VehicleConfiguration_b::*;
    import VehicleConfigurations::VehicleConfiguration_b::PartsTree::*;
    import VehicleConfigurations::VehicleConfiguration_b::Requirements::vehicle_b_Spec
    import VerificationCaseDefinitions::*;
    import VerificationCases::*;
    package VerificationCaseDefinitions{
        verification def MassTest;
        verification def AccelerationTest;
        verification def ReliabilityTest;
    }
    package VerificationCases{
        verification massTests:MassTest {
            subject = vehicle_b;
            objective {
                verify vehicleSpecification::vehicleMassRequirement{
                    redefines massActual=weighVehicle::massMeasured;
                }
            }
        }
    }
}

```

```

        action weighVehicle (
            out massMeasured:>ISQ::mass);
    }
}
package VerificationSystem{
    part massVerificationSystem{
        perform massTests;
        part scale{
            perform massTests::weighVehicle;
        }
        part operator;
    }
}
package VehicleIndividuals{
    individual a:SpatialTemporalReference_1{
        timeslice t0_t2:VehicleRoadContext_1{
            snapshot start redefines start{:>>time=0;}
            snapshot done redefines done {:>>time=2;}
        }
        snapshot t0:VehicleRoadContext_1{
            attribute t0 redefines time=0;
            snapshot t0_r:Road_1{
                :>>Road::incline =0;
                :>>Road::friction=.1;
            }
            snapshot t0_v:Vehicle_1{
                :>>Vehicle::position=0;
                :>>Vehicle::velocity=0;
                :>>Vehicle::acceleration=1.96;
                // .2 g where 1 g = 9.8 meters/sec^2
                // how do you represent state=on;
                snapshot t0_fa:FrontAxleAssembly_1{
                    snapshot t0_leftFront:Wheel_1;
                    snapshot t0_rightFront:Wheel_2;
                }
            }
        }
        snapshot t1:VehicleRoadContext_1{
            attribute t1 redefines time=1;
            snapshot t1_r:Road_1{
                :>>Road::incline =0;
                :>>Road::friction=.1;
            }
            snapshot t1_v:Vehicle_1{
                :>>Vehicle::position=.98;
                :>>Vehicle::velocity=1.96;
                :>>Vehicle::acceleration=1.96;
                // .2 g where 1 g = 9.8 meters/sec^2
                // how do you represent state=on;
                snapshot t1_fa:FrontAxleAssembly_1{
                    snapshot t1_leftFront:Wheel_1;
                    snapshot t1_rightFront:Wheel_2;
                }
            }
        }
    }
}

```

```

    }
  }
  snapshot t2:VehicleRoadContext_1{
    attribute t2 redefines time=2;
    snapshot t2_r:Road_1{
      :>>Road::incline =0;
      :>>Road::friction=.1;
    }
    snapshot t2_v:Vehicle_1{
      :>>Vehicle::position=3.92;
      :>>Vehicle::velocity=3.92;
      :>>Vehicle::acceleration=1.96;
      // .2 g where 1 g = 9.8 meters/sec^2
      // how do you represent state=on;
      snapshot t2_fa:FrontAxleAssembly_1{
        snapshot t2_leftFront:Wheel_1;
        snapshot t2_rightFront:Wheel_2;
      }
    }
  }
}

package VehicleSuperSetModel{
  import VehicleConfigurations::*;
  import VehicleConfigurations::VehicleConfiguration_a::PartsTree::*;
  import VehicleConfigurations::VehicleConfiguration_a::ActionTree::*;
  // Make vehicle_b a specific vehicle configuration from this product family
  // instead of a subset of vehicle_a. This requires that we add all
  // of vehicle_b into the superset model.
  package VariationPointDefinitions {
    variation part def TransmissionChoices:>Transmission {
      variant part transmissionAutomatic:TransmissionAutomatic;
      variant part transmissionManual:TransmissionManual;
    }
  }
  package VehiclePartsTree{
    import VariationPointDefinitions::*;
    abstract part vehicleFamily:>vehicle_a{
      // variation with nested variation
      variation part engine:Engine{
        variant part engine4Cyl:Engine4Cyl;
        variant part engine6Cyl:Engine6Cyl{
          part cylinder:Cylinder [6]{
            variation attribute diameter:LengthValue{
              variant attribute smallDiameter:LengthValue;
              variant attribute largeDiagmeter:LengthValue;
            }
          }
        }
      }
    }
    // variation point based on variation of part definition
    variation part transmissionChoices:TransmissionChoices;
    // optional variation point
    variation part sunroof:Sunroof;
  }
}

```

```

        // selection constraint
        assert constraint {
            (engine==engine::engine4Cyl &
             transmissionChoices==TransmissionChoices::transmissionManual) ^
            (engine==engine::engine6Cyl &
             transmissionChoices==TransmissionChoices::transmissionAutomatic)
        }
    }
}

package Views_Viewpoints{
    package ViewpointDefinitions{
        viewpoint def StructureViewpoint;
        viewpoint def BehaviorViewpoint;
    }
    package RenderingDefinitions{
        rendering def Table;
    }
    package ViewDefinitions{
        view def PartsTree;
    }
    package Views{
        import ViewpointDefinitions::*;
        import RenderingDefinitions::*;
        import ViewDefinitions::*;
        import VehicleConfigurations::VehicleConfiguration_b::*;
        view vehiclePartsTree:PartsTree{
            viewpoint treeDiagram:StructureViewpoint;
            expose PartsTree::*;
            rendering partsTreeTable:Table;
        }
    }
}

```


C Annex: SysML v1 to SysML v2 Transformation

C.1 General

C.1.1 Overview

This annex describes a transformation that specifies a translation from SysML v1 [SysMLv1] to SysML v2 on a semantic basis in a precise way. (In this annex, "SysML v1" refers to SysML v1.7, the last version of SysML prior to v2.0, and "SysML v2" refers to SysML as defined in this specification.)

The main intent is to provide the rules on which automated conversions of SysML v1 models to the SysML v2 standard can be developed. In addition, this annex can be considered an educational document that provides useful information for people who would like to compare using SysML v2 to using SysML v1.

More sophisticated applications of this transformation can also be envisaged. For instance, a SysML v1 conformant tool could use this transformation to implement a limited subset of the SysML v2 API that will provided "SysMLv2-like" read-only access to its SysMLv1 models for external applications.

Submission Note: For this initial submission the transformation specification will cover a restricted scope only, which will be extended in the revised submission. For the initial submission, we focus on the metaclasses of UML4SYSML that represent structural concepts. As of this submission, the latest completed version of SysML is v1.6, with v1.7 still in preparation, but the subset covered in this initial submission is not expected to change for SysML 1.7.

C.1.2 Mapping Approach

The SysML v1 to v2 transformation is specified by directional mappings between UML metaclasses (i.e., the UML4SYSML subset) and stereotypes that are part of the SysML v1 specification and set of the metaclasses included in KerML and the SysMLv2 libraries.

Each mapping is a directed relationship that reifies a semantic link between a concept belonging to the SysMLv1 scope on the source side and one concept belonging to the SysMLv2 scope on the target side. As a set, all those mappings specify a formal transformation that describes how the information encoded by the SysMLv1 concepts can be reliably represented using constructs of SysMLv2 metaclasses instances.

In this approach, a mapping is represented by a UML class that has a pair of associations. One provides the "from" end that designates the source SysML v1 concept while the other provides the "to" end that designates the target SysML v2 metaclass.

In addition to those associations, a Mapping class provides a set of operations defining how the attribute values of the target metaclass instance have to be computed based on attribute values of the reachable from the source object. The computation algorithm is provided by the body condition of those operations and expressed using OCL code.

Note that the values assigned to attributes of the target object shall be instances of the target (i.e., SysMLv2) metamodel, coming themselves from transformations of SysMLv1 objects to SysMLv2 objects. The `getMapped` and `getMappedUnique` operations are provided for this purpose. The first one returns a (possibly empty) set of values while the second returns a (possibly null) value, based on a mapping type and a target type.

Each mapping specification enables the transformation of any object that has the type specified by the "from" role to an object of the type specified by the "to" role, as long as it is not overloaded by a more specific mapping defined. In other words, assume a mapping is specified as the class "A" (i.e., that has A typing the its "from" property) it will apply to any instance of a class B if B is a subclass of A and if there is no specialization of that mapping class specified for B (i.e., that has B typing the its "from" property).

Some mapping classes have one or more qualifiers for their "from" attribute. In such a case, each of those qualifiers reflect the specific attribute of the source type (i.e. the type of the "from" attribute) that has the same name and the same type. For those specific mappings, it is expected to get one instance of the target class (as specified by the type of the "to" attribute) for each combination of value of those attributes per instance of object of the source type, assuming they pass the applicability filter as described below.

Indeed, it is also possible to restrict the applicability of a mapping specification to a specific subset of objects. This is achieved by the "filter" operation that is evaluated against each candidate object. Only objects for which this "filter" operation returns "true" shall be translated according to that mapping rules. By default, the filter operation always returns "true".

C.2 Mappings

C.2.1 Generic Mappings

C.2.1.1 Overview

Generic mapping are partial definitions of transformation rules that are intended to factorize reusable algorithms for making the global specification more compact and easier to read and to maintain. Basically they provide a default value for all the non-derived attributes of their target metaclass wherever possible, or declare an abstract operation for them otherwise. All of them have "UML::Element" defined as their source type. The operations provided by the generic mappings are redefined by their specialization, as appropriate according to the source type specified by the redefinition of their "from" attribute.

All of those generic mapping are abstract, except one (the "GenericToElement_Mapping") that is the root of all other mappings class.

C.2.1.2 Generic Mappings to KerML

C.2.1.2.1 GenericToAnnotatingElement_Mapping

This is an abstract mapping class.

General Mappings

GenericToElement_Mapping

Mapping Target

AnnotatingElement

Applicable filters

(none)

Table 6. Table GenericToAnnotatingElement_Mapping Rules

Target Attribute Rule	Specification
AnnotatingElement::annotation	Set{}

C.2.1.2.2 GenericToAnnotation_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping

Mapping Target

Annotation

Applicable filters

(none)

Table 7. Table GenericToAnnotation_Mapping Rules

Target Attribute Rule	Specification
Annotation::annotatingComment	<i>(abstract rule)</i>
Annotation::annotatedElement	<i>(abstract rule)</i>

C.2.1.2.3 GenericToAssociation_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping

GenericToClassifier_Mapping

Mapping Target

Association

Applicable filters

(none)

C.2.1.2.4 GenericToBehavior_Mapping

This is an abstract mapping class.

General Mappings

GenericToClassifier_Mapping

Mapping Target

Behavior

Applicable filters

(none)

C.2.1.2.5 GenericToClassifier_Mapping

This is an abstract mapping class.

General Mappings

GenericToType_Mapping

Mapping Target

Classifier

Applicable filters

(none)

C.2.1.2.6 GenericToConjugation_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping

Mapping Target

Conjugation

Applicable filters

(none)

Table 11. Table GenericToConjugation_Mapping Rules

Target Attribute Rule	Specification
Conjugation::originalType	<i>(abstract rule)</i>
Conjugation::conjugatedType	<i>(abstract rule)</i>

C.2.1.2.7 GenericToElement_Mapping

General Mappings

No general mappings.

Mapping Target

Element

Applicable filters

(none)

Table 12. Table GenericToElement_Mapping Rules

Target Attribute Rule	Specification
Element::identifier	null
Element::ownedRelationship	from.ownedElement->select(oclIsKindOf(Relationship)) ->collect(e self.getMappedUnique(e, Relationship_Mapping, Relationship))
Element::owningMembership	nul

Target Attribute Rule	Specification
Element::owningRelationship	if from.owner.ocIsKindOf(Relationship) then self.getMappedUnique(from.owner, Relationship_Mapping, Relationship) else null endif
Element::aliasId	Set{}
Element::humanId	null
Element::documentation	Set{}

C.2.1.2.8 GenericToConnector_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping
GenericToFeature_Mapping

Mapping Target

Connector

Applicable filters

(none)

Table 13. Table GenericToConnector_Mapping Rules

Target Attribute Rule	Specification
Connector::isDirected	false

C.2.1.2.9 GenericToExpression_Mapping

This is an abstract mapping class.

General Mappings

GenericToStep_Mapping

Mapping Target

Expression

Applicable filters

(none)

C.2.1.2.10 GenericToFeature_Mapping

This is an abstract mapping class.

General Mappings

GenericToType_Mapping

Mapping Target

Feature

Applicable filters

(none)

Table 15. Table GenericToFeature_Mapping Rules

Target Attribute Rule	Specification
Feature::ownedMembership	self.getMapped(from, GenericToFeatureMembership_Mapping, KerML::FeatureMembership) ->union(self.getMapped(from, MultiplicityElementMembership_Mapping, FeatureMembership))
Feature::isUnique	true
Feature::isOrdered	false
Feature::typing	self.getMappedUnique(from, MultiplicityBoundTyping_Mapping, FeatureTyping)

C.2.1.2.11 GenericToFeatureMembership_Mapping

This is an abstract mapping class.

General Mappings

GenericToMembership_Mapping

Mapping Target

FeatureMembership

Applicable filters

(none)

Table 16. Table GenericToFeatureMembership_Mapping Rules

Target Attribute Rule	Specification
FeatureMembership::isDerived	false
FeatureMembership::isReadOnly	false
FeatureMembership::isComposite	false
FeatureMembership::isPortion	false
FeatureMembership::isPort	false
FeatureMembership::direction	null
FeatureMembership::owningType	<i>(abstract rule)</i>
FeatureMembership::ownedMemberFeature	null
FeatureMembership::memberFeature	<i>(abstract rule)</i>

C.2.1.2.12 GenericToFeatureTyping_Mapping

This is an abstract mapping class.

General Mappings

GenericToGeneralization_Mapping

Mapping Target

FeatureTyping

Applicable filters

(none)

Table 17. Table GenericToFeatureTyping_Mapping Rules

Target Attribute Rule	Specification
FeatureTyping::type	<i>(abstract rule)</i>
FeatureTyping::typedFeature	<i>(abstract rule)</i>

C.2.1.2.13 GenericToFeatureValue_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeatureMembership_Mapping

Mapping Target

FeatureValue

Applicable filters

(none)

Table 18. Table GenericToFeatureValue_Mapping Rules

Target Attribute Rule	Specification
FeatureValue::value	<i>(abstract rule)</i>

C.2.1.2.14 GenericToFunction_Mapping

This is an abstract mapping class.

General Mappings

GenericToBehavior_Mapping

Mapping Target

Function

Applicable filters

(none)

C.2.1.2.15 GenericToGeneralization_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping

Mapping Target

Generalization

Applicable filters

(none)

Table 20. Table GenericToGeneralization_Mapping Rules

Target Attribute Rule	Specification
Generalization::general	<i>(abstract rule)</i>
Generalization::specific	<i>(abstract rule)</i>

C.2.1.2.16 GenericToMembership_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping

Mapping Target

Membership

Applicable filters

(none)

Table 21. Table GenericToMembership_Mapping Rules

Target Attribute Rule	Specification
Membership::memberName	null
Membership::aliases	Set {}
Membership::visibility	null
Membership::ownedMemberElement	null
Membership::memberElement	<i>(abstract rule)</i>
Membership::membershipOwningPackage	<i>(abstract rule)</i>

C.2.1.2.17 GenericToPackage_Mapping

This is an abstract mapping class.

General Mappings

GenericToElement_Mapping

Mapping Target

Package

Applicable filters

(none)

Table 22. Table GenericToPackage_Mapping Rules

Target Attribute Rule	Specification
Package::ownedMembership	Set{}
Package::ownedImport	Set{}

C.2.1.2.18 GenericToParameterMembership_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeatureMembership_Mapping

Mapping Target

ParameterMembership

Applicable filters

(none)

Table 23. Table GenericToParameterMembership_Mapping Rules

Target Attribute Rule	Specification
ParameterMembership::direction	KerML::FeatureDirectionKind::in

C.2.1.2.19 GenericToRelationship_Mapping

This is an abstract mapping class.

General Mappings

GenericToElement_Mapping

Mapping Target

Relationship

Applicable filters

(none)

Table 24. Table GenericToRelationship_Mapping Rules

Target Attribute Rule	Specification
Relationship::ownedRelatedElement	Set{}
Relationship::owningRelatedElement	null
Relationship::target	Set{}
Relationship::source	Set{}

C.2.1.2.20 GenericToReturnParameterMembership_Mapping

This is an abstract mapping class.

General Mappings

GenericToParameterMembership_Mapping

Mapping Target

ReturnParameterMembership

Applicable filters

(none)

Table 25. Table GenericToReturnParameterMembership_Mapping Rules

Target Attribute Rule	Specification
ReturnParameterMembership::direction	KerML::FeatureDirectionKind::out

C.2.1.2.21 GenericToStep_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeature_Mapping

Mapping Target

Step

Applicable filters

(none)

C.2.1.2.22 GenericToType_Mapping

This is an abstract mapping class.

General Mappings

GenericToPackage_Mapping

Mapping Target

Type

Applicable filters

(none)

Table 27. Table GenericToType_Mapping Rules

Target Attribute Rule	Specification
Type::isAbstract	false
Type::isSufficient	false
Type::conjugator	null

C.2.1.3 Generic Mappings to Systems

C.2.1.3.1 GenericToConjugatedPortDefinition_Mapping

This is an abstract mapping class.

General Mappings

GenericToPortDefinition_Mapping

Mapping Target

ConjugatedPortDefinition

Applicable filters

(none)

Table 28. Table GenericToConjugatedPortDefinition_Mapping Rules

Target Attribute Rule	Specification
ConjugatedPortDefinition::ownedPortConjugator	<i>(abstract rule)</i>

C.2.1.3.2 GenericToConstraintDefinition_Mapping

General Mappings

GenericToFunction_Mapping

GenericToBehavior_Mapping

Mapping Target

ConstraintDefinition

Applicable filters

(none)

C.2.1.3.3 GenericToDefinition_Mapping

This is an abstract mapping class.

General Mappings

GenericToClassifier_Mapping

Mapping Target

Definition

Applicable filters

(none)

Table 30. Table GenericToDefinition_Mapping Rules

Target Attribute Rule	Specification
Definition::isVariation	false

C.2.1.3.4 GenericToItemDefinition_Mapping

This is an abstract mapping class.

General Mappings

GenericToDefinition_Mapping

Mapping Target

ItemDefinition

Applicable filters

(none)

C.2.1.3.5 GenericToPortConjugation_Mapping

This is an abstract mapping class.

General Mappings

GenericToConjugation_Mapping

Mapping Target

PortConjugation

Applicable filters

(none)

Table 32. Table GenericToPortConjugation_Mapping Rules

Target Attribute Rule	Specification
PortConjugation::originalType	<i>(abstract rule)</i>
PortConjugation::conjugatedType	<i>(abstract rule)</i>

C.2.1.3.6 GenericToPortDefinition_Mapping

This is an abstract mapping class.

General Mappings

GenericToDefinition_Mapping

Mapping Target

PortDefinition

Applicable filters

(none)

C.2.1.3.7 GenericToUsage_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeature_Mapping

Mapping Target

Usage

Applicable filters

(none)

Table 34. Table GenericToUsage_Mapping Rules

Target Attribute Rule	Specification
Usage::isVariation	false

C.2.1.3.8 GenericToConjugatedPortTyping_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeatureTyping_Mapping

Mapping Target

ConjugatedPortTyping

Applicable filters

(none)

Table 35. Table GeneritToConjugatedPortTyping_Mapping Rules

Target Attribute Rule	Specification
ConjugatedPortTyping::portDefinition	<i>(abstract rule)</i>

C.2.2 UML4SysML

C.2.2.1 Actions

Table 36. List of all Actions Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
AcceptCallAction		
AcceptEventAction		
Action		
ActionInputPin		
AddStructuralFeatureValueAction		
AddVariableValueAction		
BroadcastSignalAction		
CallAction		
CallBehaviorAction		
CallOperationAction		
Clause		
ClearAssociationAction		
ClearStructuralFeatureAction		
ClearVariableAction		
ConditionalNode		
CreateLinkAction		
CreateLinkObjectAction		
CreateObjectAction		
DestroyLinkAction		
DestroyObjectAction		
ExpansionRegion		
InputPin		
InvocationAction		
LinkAction		
LinkEndCreationData		

SysML v1 Concept	SysML v2 Concept	Mapping Class
LinkEndData		
LinkEndDestructionData		
LoopNode		
OpaqueAction		
OutputPin		
Pin		
RaiseExceptionAction		
ReadExtentAction		
ReadIsClassifiedObjectAction		
ReadLinkAction		
ReadLinkObjectEndAction		
ReadSelfAction		
ReadStructuralFeatureAction		
ReadVariableAction		
ReclassifyObjectAction		
ReduceAction		
RemoveStructuralFeatureValueAction		
RemoveVariableValueAction		
ReplyAction		
SendObjectAction		
SendSignalAction		
SequenceNode		
StartClassifierBehaviorAction		
StartObjectBehaviorAction		
StructuralFeatureAction		
StructuredActivityNode		
TestIdentityAction		
UnmarshallAction		
ValuePin		
ValueSpecificationAction		
VariableAction		
WriteLinkAction		
WriteStructuralFeatureAction		

SysML v1 Concept	SysML v2 Concept	Mapping Class
WriteVariableAction		

C.2.2.2 Activities

Table 37. List of all Activities Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
ActivityEdge		
ActivityFinalNode		
ActivityGroup		
ActivityNode		
ActivityParameterNode		
ActivityPartition		
CentralBufferNode		
ControlFlow		
ControlNode		
DataStoreNode		
DecisionNode		
ExceptionHandler		
ExecutableNode		
FinalNode		
FlowFinalNode		
ForkNode		
InitialNode		
InterruptibleActivityRegion		
JoinNode		
MergeNode		
ObjectFlow		
ObjectNode		
ObjectNodeOrderingKind		
Variable		

C.2.2.3 Classifications

Table 38. List of all Classifications Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
AggregationKind		
BehavioralFeature		

SysML v1 Concept	SysML v2 Concept	Mapping Class
CallConcurrencyKind		
Classifier	Classifier	Classifier_Mapping
Feature		
Generalization	Superclassing	Generalization_Mapping
GeneralizationSet		
InstanceSpecification	IndividualDefinition Generalization	InstanceSpecification_Mapping InstanceSpecificationToGeneralization_Mapping
InstanceValue	Expression	InstanceValue_Mapping
Operation		
Parameter	Feature	Parameter_Mapping
ParameterDirectionKind		
ParameterSet		
Property	FeatureMembership	PropertyMembership_Mapping
RedefinableElement		
Slot	FeatureValue	Slot_Mapping
StructuralFeature	Feature FeatureMembership	StructuralFeature_Mapping StructuralFeatureMembership_Mapping
Substitution	Generalization	Substitution_Mapping

C.2.2.3.1 Classifier_Mapping

This is an abstract mapping class.

General Mappings

Namespace_Mapping

GenericToClassifier_Mapping

Mapping Source

Classifier

Mapping Target

Classifier

Applicable filters

(none)

Table 39. Table Classifier_Mapping Rules

Target Attribute Rule	Specification
Classifier::isAbstract	from.isAbstract

Target Attribute Rule	Specification
Classifier::isSufficient	false

C.2.2.3.2 Generalization_Mapping

General Mappings

DirectedRelationship_Mapping
GenericToGeneralization_Mapping

Mapping Source

Generalization

Mapping Target

Superclassing

Applicable filters

(none)

Table 40. Table Generalization_Mapping Rules

Target Attribute Rule	Specification
Superclassing::superclass	self.target().oclAsType(KerML::Type)
Superclassing::subclass	self.source().oclAsType(KerML::Type)

C.2.2.3.3 InstanceSpecification_Mapping

General Mappings

GenericToDefinition_Mapping

Mapping Source

InstanceSpecification

Mapping Target

IndividualDefinition

Applicable filters

(none)

C.2.2.3.4 InstanceSpecificationToGeneralization_Mapping

General Mappings

GenericToGeneralization_Mapping

Mapping Source

InstanceSpecification with qualifier: classifier:Classifier

Mapping Target

Generalization

Applicable filters

(none)

Table 42. Table InstanceSpecificationToGeneralization_Mapping Rules

Target Attribute Rule	Specification
Generalization::general	, GenericToClassifier_Mapping, KerML::Classifier)
Generalization::specific	

C.2.2.3.5 InstanceValue_Mapping**General Mappings**

GenericToExpression_Mapping

Mapping Source

InstanceValue

Mapping Target

Expression

Applicable filters

(none)

C.2.2.3.6 Parameter_Mapping**General Mappings**

GenericToFeature_Mapping

Mapping Source

Parameter

Mapping Target

Feature

Applicable filters

(none)

C.2.2.3.7 PropertyMembership_Mapping**General Mappings**

StructuralFeatureMembership_Mapping

Mapping Source

Property

Mapping Target

FeatureMembership

Applicable filters

(none)

Table 45. Table PropertyMembership_Mapping Rules

Target Attribute Rule	Specification
FeatureMembership::isDerived	from.isDerived
FeatureMembership::isComposite	from.isComposite

C.2.2.3.8 Slot_Mapping**General Mappings**

GenericToFeatureValue_Mapping

Mapping Source

Slot

Mapping Target

FeatureValue

Applicable filters

(none)

Table 46. Table Slot_Mapping Rules

Target Attribute Rule	Specification
FeatureValue::value	Set{}
FeatureValue::owningType	

C.2.2.3.9 StructuralFeature_Mapping**General Mappings**

GenericToFeature_Mapping

Mapping Source

StructuralFeature

Mapping Target

Feature

Applicable filters

(none)

Table 47. Table StructuralFeature_Mapping Rules

Target Attribute Rule	Specification
Feature::ownedMembership	self.getMapped(from, StructuralFeatureMembership_Mapping, FeatureMembership)
Feature::isAbstract	from.isAbstract
Feature::isUnique	from.isUnique
Feature::isOrdered	from.isOrdered
Feature::typing	self.getMapped(from, TypedElement_Mapping, FeatureTyping)

C.2.2.3.10 StructuralFeatureMembership_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeatureMembership_Mapping

Mapping Source

StructuralFeature

Mapping Target

FeatureMembership

Applicable filters

(none)

Table 48. Table StructuralFeatureMembership_Mapping Rules

Target Attribute Rule	Specification
FeatureMembership::isReadOnly	from.isReadOnly
FeatureMembership::memberFeature	self.getMappedUnique(from, StructuralFeature_Mapping, KerML::Feature)

C.2.2.3.11 Substitution_Mapping

General Mappings

GenericToGeneralization_Mapping

Mapping Source

Substitution

Mapping Target

Generalization

Applicable filters

(none)

Table 49. Table Substitution_Mapping Rules

Target Attribute Rule	Specification
Generalization::general	self.getMapped(from.contract, Classifier_Mapping, KerML::Classifier)
Generalization::specific	self.getMapped(from.substitutingClassifier, Classifier_Mapping, KerML::Classifier)

C.2.2.4 CommonBehaviors

Table 50. List of all CommonBehaviors Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
AnyReceiveEvent		
Behavior		
CallEvent		
ChangeEvent		
Event		
FunctionBehavior		
MessageEvent		
OpaqueBehavior		
SignalEvent		
TimeEvent		
Trigger		

C.2.2.4.1 AnyReceiveEvent_Mapping

General Mappings

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.2 Behavior_Mapping

General Mappings

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.3 CallEvent_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.4 ChangeEvent_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.5 Event_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.6 FunctionBehavior_Mapping

General Mappings

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.7 MessageEvent_Mapping

General Mappings

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.8 OpaqueBehavior_Mapping

General Mappings

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.9 SignalEvent_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.10 TimeEvent_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.4.11 Trigger_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.5 CommonStructure

Table 62. List of all CommonStructure Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
Abstraction	Dependency	Abstraction_Mapping
Comment	Comment Annotation	Comment_Mapping CommentToAnnotation_Mapping
Constraint	ConstraintDefinition	Constraint_Mapping
Dependency	Dependency	Dependency_Mapping
DirectedRelationship	Relationship	DirectedRelationship_Mapping
Element	Element	GenericToElement_Mapping
ElementImport	Membership	ElementImport_Mapping
MultiplicityElement	Feature FeatureMembership FeatureTyping MultiplicityRange FeatureMembership	MultiplicityBound_Mapping MultiplicityMembership_Mapping MultiplicityBoundTyping_Mapping MultiplicityElement_Mapping MultiplicityBoundMembership_Mapping
NamedElement	Membership Element	NamedElementOwnership_Mapping NamedElement_Mapping
Namespace	Package	Namespace_Mapping
PackageableElement		
PackageImport	Import	PackageImport_Mapping
ParameterableElement		
Realization	Dependency	Realization_Mapping
Relationship	Relationship	Relationship_Mapping
Type		
TypedElement	FeatureTyping	TypedElementToFeatureTyping_Mapping
Usage	Dependency	Usage_Mapping
VisibilityKind		

C.2.2.5.1 Abstraction_Mapping

General Mappings

Dependency_Mapping

Mapping Source

Abstraction

Mapping Target

Dependency

Applicable filters

(none)

C.2.2.5.2 Comment_Mapping

General Mappings

GenericToElement_Mapping

Mapping Source

Comment

Mapping Target

Comment

Applicable filters

(none)

Table 64. Table Comment_Mapping Rules

Target Attribute Rule	Specification
Comment::body	if from.body->isEmpty() " else from.body endif

C.2.2.5.3 CommentToAnnotation_Mapping

General Mappings

GenericToAnnotation_Mapping

Mapping Source

Comment with qualifier: annotatedElement:Element

Mapping Target

Annotation

Applicable filters

(none)

Table 65. Table CommentToAnnotation_Mapping Rules

Target Attribute Rule	Specification
Annotation::annotatingComment	self.getMapped(from.relatedElement, Element_Mapping, Element)

Target Attribute Rule	Specification
Annotation::annotatedElement	self.getMapped(from.relatedElement, Element_Mapping, Element)
Annotation::annotatingComment	
Annotation::annotatedElement	

C.2.2.5.4 Constraint_Mapping

General Mappings

GenericToConstraintDefinition_Mapping

Mapping Source

Constraint

Mapping Target

ConstraintDefinition

Applicable filters

(none)

C.2.2.5.5 Dependency_Mapping

General Mappings

DirectedRelationship_Mapping

Mapping Source

Dependency

Mapping Target

Dependency

Applicable filters

(none)

Table 67. Table Dependency_Mapping Rules

Target Attribute Rule	Specification
Dependency::supplier	from.target->collect(e self.getMappedUnique(e, Element_Mapping, Element))
Dependency::client	from.source->collect(e self.getMappedUnique(e, Element_Mapping, Element))

C.2.2.5.6 DirectedRelationship_Mapping

This is an abstract mapping class.

General Mappings

Relationship_Mapping

Mapping Source

DirectedRelationship

Mapping Target

Relationship

Applicable filters

(none)

Table 68. Table DirectedRelationship_Mapping Rules

Target Attribute Rule	Specification
Relationship::target	from.target->collect(e self.getMappedUnique(e, Element_Mapping, Element))
Relationship::source	from.source->collect(e self.getMappedUnique(e, Element_Mapping, Element))

C.2.2.5.7 Element_Mapping

General Mappings

No general mappings.

Mapping Source

Element

Mapping Target

Element

Applicable filters

(none)

Table 69. Table Element_Mapping Rules

Target Attribute Rule	Specification
Element::identifier	null
Element::ownedRelationship	from.ownedElement->select(oclIsKindOf(Relationship)) ->collect(e self.getMappedUnique(e, Relationship_Mapping, Relationship))
Element::owningMembership	null
Element::owningRelationship	if from.owner.oclIsKindOf(Relationship) then self.getMappedUnique(from.owner, Relationship_Mapping, Relationship) else null endif
Element::aliasId	Set {}
Element::humanId	null
Element::documentation	Set {}

C.2.2.5.8 ElementImport_Mapping

General Mappings

GenericToMembership_Mapping

Mapping Source

ElementImport

Mapping Target

Membership

Applicable filters

(none)

Table 70. Table ElementImport_Mapping Rules

Target Attribute Rule	Specification
Membership::aliases	from.alias->asSet()
Membership::visibility	Helper.getKerMLVisibilityKind(from.visibility)
Membership::membershipOwningPackage	self.getMappedUnique(from.importingNamespace, Namespace_Mapping, KerML::Package)
Membership::memberElement	self.getMappedUnique(from.importedElement, Element_Mapping, KerML::Element)
Membership::memberName	from.importedElement.name

C.2.2.5.9 LowerBoundTyping_Mapping

General Mappings

MultiplicityBoundTyping_Mapping

Mapping Source

MultiplicityElement

Mapping Target

FeatureTyping

Applicable filters

(none)

Table 71. Table LowerBoundTyping_Mapping Rules

Target Attribute Rule	Specification
FeatureTyping::typedFeature	self.getMappedUnique(from, MultiplicityLowerBoun_Mapping, KerML::Feature)

C.2.2.5.10 MultiplicityBound_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeature_Mapping

Mapping Source

MultiplicityElement

Mapping Target

Feature

Applicable filters

(none)

Table 72. Table MultiplicityBound_Mapping Rules

Target Attribute Rule	Specification
Feature::ownedMembership	Set{}
Feature::typing	

C.2.2.5.11 MultiplicityBoundMembership_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeatureMembership_Mapping

Mapping Source

MultiplicityElement

Mapping Target

FeatureMembership

Applicable filters

(none)

Table 73. Table MultiplicityBoundMembership_Mapping Rules

Target Attribute Rule	Specification
FeatureMembership::isComposite	true
FeatureMembership::ownedMemberFeature	self.memberFeature()
FeatureMembership::owningType	self.getMappedUnique(from, MultiplicityElement_Mapping, KerML::MultiplicityRange)

Target Attribute Rule	Specification
FeatureMembership::memberFeature	self.getMappedUnique(from, MultiplicityElement_Mapping, MultiplicityRange)

C.2.2.5.12 MultiplicityBoundTyping_Mapping

This is an abstract mapping class.

General Mappings

GenericToFeatureTyping_Mapping

Mapping Source

MultiplicityElement

Mapping Target

FeatureTyping

Applicable filters

(none)

Table 74. Table MultiplicityBoundTyping_Mapping Rules

Target Attribute Rule	Specification
FeatureTyping::type	KerML::Integer
FeatureTyping::typedFeature	<i>(abstract rule)</i>

C.2.2.5.13 MultiplicityElement_Mapping

General Mappings

GenericToFeature_Mapping

Mapping Source

MultiplicityElement

Mapping Target

MultiplicityRange

Applicable filters

(none)

Table 75. Table MultiplicityElement_Mapping Rules

Target Attribute Rule	Specification
MultiplicityRange::ownedMembership	self.getMapped(from, MultiplicityBoundMembership, FeatureMembership)

Target Attribute Rule	Specification
MultiplicityRange::ownedImport	Set{}
MultiplicityRange::isUnique	from.isUnique
MultiplicityRange::identifier	if oclIsKindOf(NamedElement) then from.name+'_Multiplicity' else null endif

C.2.2.5.14 MultiplicityLowerBound_Mapping

General Mappings

MultiplicityBound_Mapping

Mapping Source

MultiplicityElement

Mapping Target

Feature

Applicable filters

(none)

C.2.2.5.15 MultiplicityMembership_Mapping

General Mappings

GenericToFeatureMembership_Mapping

Mapping Source

MultiplicityElement

Mapping Target

FeatureMembership

Applicable filters

(none)

Table 77. Table MultiplicityMembership_Mapping Rules

Target Attribute Rule	Specification
FeatureMembership::isComposite	true
FeatureMembership::ownedMemberFeature	self.memberFeature()
FeatureMembership::memberFeature	self.getMappedUnique(from, MultiplicityElement_Mapping, MultiplicityRange)
FeatureMembership::owningType	self.getMappedUnique(from, StructuralFeature_Mapping, KerML::Feature)

C.2.2.5.16 MultiplicityUpperBound_Mapping

General Mappings

MultiplicityBound_Mapping

Mapping Source

MultiplicityElement

Mapping Target

Feature

Applicable filters

(none)

C.2.2.5.17 NamedElement_Mapping

This is an abstract mapping class.

General Mappings

GenericToElement_Mapping

Mapping Source

NamedElement

Mapping Target

Element

Applicable filters

(none)

C.2.2.5.18 NamedElementOwnership_Mapping

General Mappings

GenericToMembership_Mapping

Mapping Source

NamedElement

Mapping Target

Membership

Applicable filters

(none)

Table 80. Table NamedElementOwnership_Mapping Rules

Target Attribute Rule	Specification
Membership::ownedMemberElement	self.memberElement()
Membership::memberElement	self.getMappedUnique(from, GenericToElement_Mapping, Element)
Membership::visibility	Helper.getKerMLVisibilityKind(from.visibility)
Membership::memberName	from.name
Membership::membershipOwningPackage	if from.owner->isEmpty() then Helper.globalNamespace() else self.getMappedUnique(from.owner, Namespace_Mapping, KerML::Package) endif

C.2.2.5.19 Namespace_Mapping

This is an abstract mapping class.

General Mappings

GenericToElement_Mapping

Mapping Source

Namespace

Mapping Target

Package

Applicable filters

(none)

Table 81. Table Namespace_Mapping Rules

Target Attribute Rule	Specification
Package::ownedMembership	from.ownedElement->collect(e self.getMappedUnique(e, NamedElementOwnership_Mapping, KerML::Membership)) ->union(from.elementImport->collect(i self.getMappedUnique(i, ElementImport_Mapping, KerML::Membership)) ->asSet()
Package::ownedImport	from.packageImport->collect(p self.getMappedUnique(p, PackageImport_Mapping, KerML::Import))

C.2.2.5.20 PackageImport_Mapping**General Mappings**

DirectedRelationship_Mapping

Mapping Source

PackageImport

Mapping Target

Import

Applicable filters

(none)

Table 82. Table PackageImport_Mapping Rules

Target Attribute Rule	Specification
Import::importedPackage	self.getMappedUnique(from.importedPackage, Namespace_Mapping, KerML::Package)
Import::visibility	Helper.getKerMLVisibilityKind(from.visibility)
Import::importOwningPackage	self.getMappedUnique(from.importingNamespace, Namespace_Mapping, KerML::Package)

C.2.2.5.21 Realization_Mapping

General Mappings

GenericToGeneralization_Mapping
Abstraction_Mapping

Mapping Source

Realization with qualifier: supplier:NamedElement, client:NamedElement

Mapping Target

Dependency

Applicable filters

(none)

Table 83. Table Realization_Mapping Rules

Target Attribute Rule	Specification
Dependency::general	from.client
Dependency::specific	from.supplier

C.2.2.5.22 Relationship_Mapping

This is an abstract mapping class.

General Mappings

GenericToRelationship_Mapping

Mapping Source

Relationship

Mapping Target

Relationship

Applicable filters

(none)

Table 84. Table Relationship_Mapping Rules

Target Attribute Rule	Specification
Relationship::ownedRelatedElement	from.ownedElement->collect(e self.getMappedUnique(e, Element_Mapping, Element))
Relationship::owningRelatedElement	self.getMappedUnique(from.owner, Element_Mapping, Element)
Relationship::target	<i>(abstract rule)</i>
Relationship::source	<i>(abstract rule)</i>

C.2.2.5.23 TypedElement_Mapping

General Mappings

GenericToFeatureTyping_Mapping

Mapping Source

TypedElement

Mapping Target

FeatureTyping

Applicable filters

from.type->notEmpty() and not from.ocIsKindOf(UML::ValueSpecification)

Table 85. Table TypedElement_Mapping Rules

Target Attribute Rule	Specification
FeatureTyping::type	self.getMapped(from.type, GenericToType_Mapping, KerML::Type)
FeatureTyping::typedFeature	self.getMappedUnique(from, GenericToFeature_Mapping, KerML::Feature)

C.2.2.5.24 UpperBoundTyping_Mapping

General Mappings

MultiplicityBoundTyping_Mapping

Mapping Source

MultiplicityElement

Mapping Target

FeatureTyping

Applicable filters

(none)

Table 86. Table UpperBoundTyping_Mapping Rules

Target Attribute Rule	Specification
FeatureTyping::typedFeature	self.getMappedUnique(from, MultiplicityLowerBoun_Mapping, KerML::Feature)

C.2.2.5.25 Usage_Mapping

General Mappings

Dependency_Mapping

Mapping Source

Usage

Mapping Target

Dependency

Applicable filters

(none)

C.2.2.6 InformationFlows

Table 88. List of all InformationFlows Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
InformationFlow	Relationship	InformationFlow_Mapping
InformationItem	ItemDefinition	InformationItem_Mapping

C.2.2.6.1 InformationFlow_Mapping

General Mappings

Relationship_Mapping

Mapping Source

InformationFlow

Mapping Target

Relationship

Applicable filters

(none)

Table 89. Table InformationFlow_Mapping Rules

Target Attribute Rule	Specification
Relationship::conveyed	self.getMapped(from.conveyed, Classifier_Mapping, Track 4 - Metamodel Development::Models::1. Abstract Syntax::Core::Classifiers::Classifier)
Relationship::source	self.getMapped(from.informationSource, Element_Mapping, Track 4 - Metamodel Development::Models::1. Abstract Syntax::Root::Elements::Element)
Relationship::target	self.getMapped(from.informationTarget, Element_Mapping, Track 4 - Metamodel Development::Models::1. Abstract Syntax::Root::Elements::Element)

C.2.2.6.2 InformationItem_Mapping**General Mappings**

Classifier_Mapping

Mapping Source

InformationItem

Mapping Target

ItemDefinition

Applicable filters

(none)

Table 90. Table InformationItem_Mapping Rules

Target Attribute Rule	Specification
ItemDefinition::represented	self.getMapped(from.represented, Classifier_Mapping, Track 4 - Metamodel Development::Models::1. Abstract Syntax::Core::Classifiers::Classifier)

C.2.2.7 Interactions**Table 91. List of all Interactions Mapping Specifications**

SysML v1 Concept	SysML v2 Concept	Mapping Class
ActionExecutionSpecification		
BehaviorExecutionSpecification		
CombinedFragment		
ConsiderIgnoreFragment		
Continuation		
DestructionOccurrenceSpecification		
ExecutionOccurrenceSpecification		
ExecutionSpecification		
Gate		
GeneralOrdering		

SysML v1 Concept	SysML v2 Concept	Mapping Class
Interaction		
InteractionConstraint		
InteractionFragment		
InteractionOperand		
InteractionOperatorKind		
InteractionUse		
Lifeline		
Message		
MessageEnd		
MessageOccurrenceSpecification		
OccurrenceSpecification		
PartDecomposition		
StateInvariant		

C.2.2.8 Packages

Table 92. List of all Packages Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
Extension		
ExtensionEnd		
Image		
Model	Package	Model_Mapping
Package	Package	Package_Mapping
PackageMerge		
Profile		
ProfileApplication		
Stereotype		

C.2.2.8.1 Model_Mapping

General Mappings

Package_Mapping

Mapping Source

Model

Mapping Target

Package

Applicable filters

(none)

C.2.2.8.2 Package_Mapping

General Mappings

Namespace_Mapping

Mapping Source

Package

Mapping Target

Package

Applicable filters

(none)

Table 94. Table Package_Mapping Rules

Target Attribute Rule	Specification
Package::URI	

C.2.2.9 SimpleClassifiers

Table 95. List of all SimpleClassifiers Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
BehavioredClassifier	Classifier	BehavioredClassifier_Mapping
DataType	DataType	DataType_Mapping
Enumeration	DataType	Enumeration_Mapping
EnumerationLiteral		
Interface	InterfaceDefinition	Interface_Mapping
InterfaceRealization		
PrimitiveType	DataType	PrimitiveType_Mapping
Reception		
Signal	Classifier	Signal_Mapping

C.2.2.9.1 BehavioredClassifier_Mapping

This is an abstract mapping class.

General Mappings

Classifier_Mapping

Mapping Source

BehavioeredClassifier

Mapping Target

Classifier

Applicable filters

(none)

Table 96. Table BehavioeredClassifier_Mapping Rules

Target Attribute Rule	Specification
Classifier::classifierBehavior	
Classifier::interfaceRealization	
Classifier::ownedBehavior	

C.2.2.9.2 DataType_Mapping

General Mappings

Classifier_Mapping

Mapping Source

DataType

Mapping Target

DataType

Applicable filters

(none)

C.2.2.9.3 Enumeration_Mapping

General Mappings

DataType_Mapping

Mapping Source

Enumeration

Mapping Target

DataType

Applicable filters

(none)

C.2.2.9.4 Interface_Mapping

General Mappings

Classifier_Mapping

Mapping Source

Interface

Mapping Target

InterfaceDefinition

Applicable filters

(none)

C.2.2.9.5 PrimitiveType_Mapping

General Mappings

DataType_Mapping

Mapping Source

PrimitiveType

Mapping Target

DataType

Applicable filters

(none)

C.2.2.9.6 Signal_Mapping

General Mappings

Classifier_Mapping

Mapping Source

Signal

Mapping Target

Classifier

Applicable filters

(none)

C.2.2.10 StateMachines

Table 102. List of all StateMachines Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
ConnectionPointReference		
FinalState		
Pseudostate		
Region		
State		
StateMachine		
Transition		
TransitionKind		
Vertex		

C.2.2.11 StructuredClassifiers

Table 103. List of all StructuredClassifiers Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
Association	Association	Association_Mapping
AssociationClass	ItemDefinition	AssociationClass_Mapping
Class	ItemDefinition	Class_Mapping
ConnectableElement		
Connector	Connector	Connector_Mapping
ConnectorEnd	FeatureTyping Feature Feature	ConnectorEndRoleToFeatureTyping_Mapping ConnectorEndToFeature_Mapping ConnectorEndRoleToFeature_Mapping
ConnectorKind		
EncapsulatedClassifier		
Port		
StructuredClassifier		

C.2.2.11.1 Association_Mapping

General Mappings

GenericToAssociation_Mapping

Mapping Source

Association

Mapping Target

Association

Applicable filters

(none)

C.2.2.11.2 AssociationClass_Mapping**General Mappings**

Class_Mapping
Association_Mapping

Mapping Source

AssociationClass

Mapping Target

ItemDefinition

Applicable filters

(none)

C.2.2.11.3 Class_Mapping**General Mappings**

GenericToItemDefinition_Mapping

Mapping Source

Class

Mapping Target

ItemDefinition

Applicable filters

(none)

C.2.2.11.4 ConnectableElement_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.11.5 ConnectableElementTemplateParameter_Mapping

General Mappings

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.11.6 Connector_Mapping

General Mappings

GenericToConnector_Mapping

Mapping Source

Connector

Mapping Target

Connector

Applicable filters

(none)

C.2.2.11.7 ConnectorEnd_Mapping

General Mappings

GenericToFeature_Mapping

Mapping Source

ConnectorEnd

Mapping Target

Feature

Applicable filters

(none)

C.2.2.11.8 ConnectorEndRoleToFeature_Mapping

General Mappings

GenericToFeature_Mapping

Mapping Source

ConnectorEnd

Mapping Target

Feature

Applicable filters

(none)

Table 111. Table ConnectorEndRoleToFeature_Mapping Rules

Target Attribute Rule	Specification
Feature::typing	self.getMapped(from, ConnectorRoleToFeatureTyping_Mapping, KerML::FeatureTyping)

C.2.2.11.9 ConnectorEndRoleToFeatureTyping_Mapping

General Mappings

GenericToFeatureTyping_Mapping

Mapping Source

ConnectorEnd

Mapping Target

FeatureTyping

Applicable filters

(none)

Table 112. Table ConnectorEndRoleToFeatureTyping_Mapping Rules

Target Attribute Rule	Specification
FeatureTyping::type	from.type
FeatureTyping::typedFeature	self.getMappedUnique(from.role, ConnectorEndToFeature_Mapping, KerML::Feature)

C.2.2.11.10 ConnectorEndToFeatureMembership_Mapping

General Mappings

GenericToFeatureMembership_Mapping

Mapping Source

Element

Mapping Target

FeatureMembership

Applicable filters

(none)

C.2.2.11.11 EncapsulatedClassifier_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.11.12 Port_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.11.13 StructuredClassifier_Mapping**General Mappings**

No general mappings.

Mapping Source

No source element.

Mapping Target

No target element.

Applicable filters

(none)

C.2.2.12 UseCases

Table 117. List of all UseCases Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
Actor	Class	Actor_Mapping
Extend	Relationship	Extend_Mapping
ExtensionPoint		
Include	Relationship	Include_Mapping
UseCase	CaseDefinition	UseCase_Mapping

C.2.2.12.1 Actor_Mapping

General Mappings

Classifier_Mapping

Mapping Source

Actor

Mapping Target

Class

Applicable filters

(none)

C.2.2.12.2 Extend_Mapping

General Mappings

DirectedRelationship_Mapping

Mapping Source

Extend

Mapping Target

Relationship

Applicable filters

(none)

C.2.2.12.3 Include_Mapping

General Mappings

DirectedRelationship_Mapping

Mapping Source

Include

Mapping Target

Relationship

Applicable filters

(none)

C.2.2.12.4 UseCase_Mapping

General Mappings

Classifier_Mapping

Mapping Source

UseCase

Mapping Target

CaseDefinition

Applicable filters

(none)

C.2.2.13 Values

Table 122. List of all Values Mapping Specifications

SysML v1 Concept	SysML v2 Concept	Mapping Class
Duration		
DurationConstraint		
DurationInterval		
DurationObservation		
Expression		
Interval		
IntervalConstraint		
LiteralBoolean	LiteralBoolean	LiteralBoolean_Mapping

SysML v1 Concept	SysML v2 Concept	Mapping Class
LiteralInteger	LiteralInteger	LiteralInteger_Mapping
LiteralNull	NullExpression	LiteralNull_Mapping
LiteralReal	LiteralReal	LiteralReal_Mapping
LiteralSpecification		
LiteralString	LiteralString	LiteralString_Mapping
LiteralUnlimitedNatural	LiteralInteger LiteralUnbounded	LiteralUnlimitedToInteger_Mapping LiteralUnlimitedToUnbounded_Mapping
Observation		
OpaqueExpression		
StringExpression		
TimeConstraint		
TimeExpression		
TimeInterval		
TimeObservation		
ValueSpecification	Expression	ValueSpecification_Mapping

C.2.2.13.1 LiteralBoolean_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralBoolean

Mapping Target

LiteralBoolean

Applicable filters

(none)

Table 123. Table LiteralBoolean_Mapping Rules

Target Attribute Rule	Specification
LiteralBoolean::value	false

C.2.2.13.2 LiteralInteger_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralInteger

Mapping Target

LiteralInteger

Applicable filters

(none)

Table 124. Table LiteralInteger_Mapping Rules

Target Attribute Rule	Specification
LiteralInteger::value	false

C.2.2.13.3 LiteralNull_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralNull

Mapping Target

NullExpression

Applicable filters

(none)

C.2.2.13.4 LiteralReal_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralReal

Mapping Target

LiteralReal

Applicable filters

(none)

Table 126. Table LiteralReal_Mapping Rules

Target Attribute Rule	Specification
LiteralReal::value	false

C.2.2.13.5 LiteralString_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralString

Mapping Target

LiteralString

Applicable filters

(none)

Table 127. Table LiteralString_Mapping Rules

Target Attribute Rule	Specification
LiteralString::value	if from.value.ocllsUndefined() then " else from.value endif

C.2.2.13.6 LiteralUnlimitedToInteger_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralUnlimitedNatural

Mapping Target

LiteralInteger

Applicable filters

(none)

Table 128. Table LiteralUnlimitedToInteger_Mapping Rules

Target Attribute Rule	Specification
LiteralInteger::value	false

C.2.2.13.7 LiteralUnlimitedToUnbounded_Mapping

General Mappings

ValueSpecification_Mapping

Mapping Source

LiteralUnlimitedNatural

Mapping Target

LiteralUnbounded

Applicable filters

(none)

C.2.2.13.8 ValueSpecification_Mapping**General Mappings**

GenericToFeature_Mapping

Mapping Source

ValueSpecification

Mapping Target

Expression

Applicable filters

(none)

Table 130. Table ValueSpecification_Mapping Rules

Target Attribute Rule	Specification
Expression::typing	self.getMapped(from, TypedElement_Mapping, FeatureTyping)

C.2.2.14 Primitive Types**C.2.2.15 UML StandardProfile****Table 132. List of all UML StandardProfile Mapping Specifications**

SysML v1 Concept	SysML v2 Concept	Mapping Class
Realization		
Type		

C.2.3 SysML v1.6**C.2.3.1 Model Elements****C.2.3.2 Blocks****C.2.3.3 Ports and Flows****C.2.3.4 Constraint Blocks****C.2.3.5 Activities****C.2.3.6 Allocations****C.2.3.7 Requirements****C.2.3.8 Profiles & Model Libraries**

C.2.3.8.1 ControlValues

C.2.3.8.2 PrimitiveValueTypes

C.2.3.8.3 UnitAndQuantityKind