



System Structure and Parameterization

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This document is a current working draft of the System Structure and Parameterization Standard (SSP). **It is unreleased, and does not constitute a standard of the Modelica Association.**

Contact the SSP development group at map-ssp_projectlead@googlegroups.com.

History / Road Map

Version	Date	Remarks
1.0	2019-03-05	First Public Release of SSP
1.0.1	2022-07-25	Public Release of SSP 1.0.1

Please report issues that you find with this specification to map-ssp_projectlead@googlegroups.com.

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If you have improvement suggestions, please send them to the SSP development group at map-ssp_projectlead@googlegroups.com.

Abstract

This document defines the SSP standard as a tool-independent format for the description, packaging and exchange of system structures and their parameterization. The standard is comprised of a set of XML-based formats to describe a network of component models with their signal flow and parametrization, as well as a ZIP-based packaging format for efficient distribution of entire systems, including any referenced models and other resources.

About SSP

Conventions used in this Document

- The key words **MUST**, **MUST NOT**, **REQUIRED**, **SHALL**, **SHALL NOT**, **SHOULD**, **SHOULD NOT**, **RECOMMENDED**, **MAY**, and **OPTIONAL** in this document are to be interpreted as described in RFC 2119 [RFC2119].
- Non-normative text is given in square brackets in italic font: [*especially examples are defined in this style.*].

1. Overview

SSP is a tool-independent format for the description, packaging and exchange of system structures and their parameterization. The standard is comprised of a set of XML-based formats to describe a network of component models with their signal flow and parametrization, as well as a ZIP-based packaging format for efficient distribution of entire systems, including any referenced models and other resources. This description is tool neutral and is intended to be used primarily as an exchange format of simulation system descriptions between different tools.

SSP can be seen as an extension to the FMI (Functional Mockup Interface) standard [FMI20]. FMI describes a tool independent standard to exchange single simulation models. Using SSP, complete systems consisting of multiple interconnected simulation models can be defined with the desired signal flow and also with the wanted parameterization of each single model as well as the parameters for the complete system. This system topology can include hierarchies of sub-systems for proper structuring of the overall system. Along the signal flow, unit definitions can be used for automatic unit conversion or unit checking. Parameters can be derived from other parameters to be able to introduce dependencies of parameters between different components or to assure consistent use of same values for multiple components where needed. While SSP is closely aligned to FMI it can also be used with components of other formats than FMI.

1.1. Properties and Guiding Ideas

This section introduces the basic properties and guiding principles that underly the design of the SSP standard:

Tool independence: The core intent of SSP is to enable the exchange of partial and complete simulation systems between tools. In consequence any tool-specific data is not stored in the standard schema and will be lost during transfer between implementations. However specific data can be stored in customized annotations for reuse in the same tool. Additional common data for use across tools can also be standardized as layered standards (cf. Section 2.1.1).

Simplicity: SSP is focused on the possibility to exchange complete or partial topologies and parameters between different tools as simply as possible, while retaining essential information. This optionally also includes basic graphical information, to ensure basic recognizability, while eschewing the complexities of full and exact graphical model exchange. This approach also differentiates SSP from systems engineering standards like SysML: By focusing on simplicity and simulation-related features, SSP avoids the complexities that have plagued the tool-independent exchange of SysML models, enabling a wider adoption across the tool landscape.

Maximum Reuseability: SSP contributes to maximizing reusability of models and parameters across tools and use cases. SSP can be used to specify required interfaces of a single component without the need to build a running model. Such an interface specification can be used as a template for the implementation of a model. In consequence compatibility between different implementations can be guaranteed, ensuring that these implementations will fit into the overall system structure. The feature of automated unit conversion further reduces the need for adaptations between uses. Mechanisms like signal dictionaries support simplified signal matching even across hierarchies, without the need to adjust all intervening interfaces. Hierarchical structures enable encapsulation and combination of small components into subsystems that can be reused in larger subsystems.

1.2. Typical Use cases

To understand the value of SSP, five basic use cases are listed below. These use cases are driven by the idea of collaboration of different departments either in one organization or across organizations. Additionally, a systems engineering approach is used, where a system design is performed at an early stage before the implementation of each component is completed.

It is also very important to keep in mind that SSP is defined as a tool independent exchange format. All elements of SSP can be used in different tools. Hence for every use case the most appropriate tool can be used and the result can be stored with SSP and imported by another tool for the next use case.

Another strength of SSP is due to its simple syntax that users can easily write their own software to read, generate or manipulate SSP files and exchange them with other tools that support SSP.

1.2.1. Designing a simulation structure

For the simulation of complex systems, first a design of this system should be created. From a simulation perspective, each component has to be described with its inputs and outputs and its required parameters. This can be done using SSP by defining the wrapper of this component with an empty Component element comprising the connectors for the inputs and outputs and the component's parameters.

The interaction of the components is defined by the connections. **Connections in SSP are always causal.** Connections can be made directly between components or via signal dictionaries. A signal dictionary is a collection of signals similar to a bus concept (e.g. like a CAN bus). During the design phase of a system, a signal dictionary can be a good way to predefine the available signal connections.

If the system has global parameters that shall be propagated to multiple components, the definition can also be made at system level. The mapping to the parameters of the components can be realized either using connections or through parameter bindings that can include parameter mappings.

1.2.2. SSP as definition of component interfaces and parameterization as template

The main result of the design of the complete simulation structure is the definition of all needed components and the used parameterization structure. Each component can be used as a design template for the implementation – including the wanted parameters. The system designer extracts each component into a separate SSP file as preparation for the implementation and sends it to the implementor.

The implementor of the component can import this SSP file as a template in his authoring tool and directly code the behavior using the defined input signals and the definition of the parameters to calculate the defined output signals.

After completion of the implementation, the component can be returned as a running entity in an SSP package file for insertion into the complete system structure by the integrator. The integrator can decide whether to merge the components from different sources into one file or use the components as references by using the appropriate mechanisms in SSP to just link to the original SSP files. The latter approach has the benefit that the components can be used "untouched" and any "warranty" given by the author of the component is not corrupted. Even traceability information can be retained this way.

1.2.3. SSP as central parameterization description and syntax for other parameterization databases

A good system design can be used for various applications. The structure keeps the same for all these applications. The parameter settings are used to differentiate the applications. Therefore a good parametrization concept is important to facilitate this reuse. SSP supports the creation of a central parameterization structure for entire systems. The SSP parameter data model can be used to integrate parameters from various sources, including external parameter databases, which can export their parameter data as SSP data sets. Through the URI-based addressing mechanism, tools can support direct access to such databases from system structure descriptions.

1.2.4. SSP as particular instances of ready-to-simulate simulation systems

After implementation of all components and provisioning of the parameter settings for a particular system everything is in place for running simulations. All these entities can be stored in one single SSP package, which can be imported by the executing system for running the simulation. Depending on the execution system, it might be necessary to define additional settings for the solver or other execution algorithms. The core SSP standard does not include these execution-specific settings, but layered standards will be defined to include those settings.

These complete instances of simulation systems can also be used as an archive for traceability purposes.

1.2.5. SSP for reuse of system structure elements during development

As an example, a system structure defined originally for software-in-the-loop testing can also be reused for hardware-in-the-loop testing. Where FMI enables the reuse of individual models across platforms, SSP enables the reuse of complete systems and subsystems, including their configurations, basic layouts, and parameters.

Data management tools can control the lifecycle of the SSP-based system structures. There is an increasing desire to reuse environment models to provide proven, consistent solutions for the validation of controller models in different projects and development stages (e.g., for virtual validation and HIL simulations).

Data management environments provide capabilities for managing model compositions, handling variants of systems and managing the parameter and signal interfaces of the different model systems.


The SSP approach enables the sharing of standardized system structure descriptions between data management, integration and configuration tools for SIL, MIL and HIL scenarios.

1.3. Feature Overview

- Hierarchical (multi-level) description of systems of connected components
- Use of different kind of components: FMUs and external SSPs/SSDs, extensible to other models
- Binding of parameters both at component and system-level, including automatic unit-transformations and name-mapping
- Signal dictionaries support cross-hierarchical signal pools (e.g for buses)
- Packaging of SSDs, FMUs, Parameters, ... into one bundle (SSP)
- Light-weight support for variant handling at SSP level (multiple SSDs sharing components, parameters, resources)
- Optional exchange of graphical information (similar display across tools)
- URI references to all resources: Integration with other systems via URIs and usage of subsystems in a read-only manner

1.4. Acknowledgements

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1.5. Changes in 1.0.1

The following changes were performed as part of the 1.0.1 maintenance release:

- Correct version string for 1.0 release (Issue #54)
- Clarify that GTypeChoice is optional for connectors (Issue #80)
- Clarify use of binary connectors (Issue #98)
- Clarify interaction with structured variable naming convention in FMI (Issue #59)
- Clarify icon rotation specification (Issue #29)
- Add non-normative comment on empty/missing source attribute of components (Issue #82)
- Clarify connector geometry override (Issue #30)
- Add further examples of graphical notation (Issue #42)
- Minor typographical fixes (Issues #56, #57, #58)

Note that there were no changes to the XML Schema files of the standard.



2. SSP Common Concepts

2.1. Extensibility

The SSP standard allows the set of data and meta-data stored and transported via SSP file formats to be extended by tools and users through three extension mechanisms: Annotations, extra files and MIME type-based format dispatch.

2.1.1. Annotation Mechanism

All XML-based file formats defined in the SSP standard allow optional `ssc:Annotation` elements to be inserted in all XML elements that represent entities of the underlying data model. This is achieved through the `ssc:TAnnotations` type defined in Section 4.2. Each `ssc:Annotation` element contains a required `type` attribute, which contains the namespace for that annotation, as defined in Section 2.1.3. The content of the `ssc:Annotation` element **CAN** be arbitrary XML data, and **CAN** make use of XML namespaces and XML schemas for combined validation where appropriate.

2.1.2. Extra Files Mechanism

The System Structure Package (SSP) file format is a ZIP-based packaging format, and thus not XML-based. It offers a separate mechanism to include additional data and meta-data into the package format through the reserved `extra/` ZIP entry prefix (i.e. top-level directory), as defined in Chapter 3. Files are placed inside sub-directories under that top-level directory using the namespace as defined in Section 2.1.3 as part of the sub-directory name. The content of files and further sub-directories placed in those sub-directories are unrestricted.

2.1.3. Extension Namespaces

Both annotations and extra files extensions make use of a namespace mechanism based on reverse domain notation: The originator of a specification for additional data specifies a domain name under their control as the namespace for the additional data, in order to avoid conflicts due to name collisions. The namespace is used in reverse domain notation for the type attributes in the annotation mechanism and as part of the file entry prefix under `extra/` in the extra files mechanism. All namespaces under both the `org.modelica` and `org.ssp-standard` domains are reserved for use in future layered standards (see below).

[For example, extensions defined by the Modelica Association might make use of the `org.modelica.ssp` namespace. This could lead to annotations with a type attribute of `org.modelica.ssp.something`, and/or extra files under the `extra/org.modelica.ssp.something` sub-directory.]

2.1.4. MIME-type based format dispatch

In all places where SSP file formats reference additional, potentially external, data, the reference not only carries a source specification (indicating where the data can be located, if it is not inlined), but also a MIME type attribute, specifying the file format of the data being referenced. The base standard specifies a minimum set of MIME types and related file formats (including specifically the SSP-defined file formats and FMI) that must be supported by implementations.

However implementations are free to support additional MIME types and file formats where sensible, and the exact semantics of support for additional file formats can be specified through layered standards, as described below.

In this fashion extension of SSP to support pre-existing, new or domain-specific file formats after the base standard has been finalized can be realized, as long as the file format can be semantically mapped to the SSP concepts already in place.

2.2. Versioning and Layered Standards

The SSP standard uses semantic version numbers, as defined in [SV200], where the standard version consists of a triple of version numbers, consisting of major version, minor version, and patch version numbers [e.g. *1.2.3* for major version 1, minor version 2 and patch version 3].

- Major versions will introduce changes that are neither backward nor forward-compatible, including changes to the XML schemas to include new non-ignorable content.
- Minor versions will only contain clarifications and include new layered standards, which may add new ignorable XML content, as defined below, into the core standard document, indicating that the standard needs to be supported by all conforming implementations.
- Patch versions will only change explanatory text of the standard, make formerly defined content clearer, without any other changes to the XML schemas or other content definitions. For this reason, the version number attribute of all SSP files will only contain major and minor version numbers and not the patch version number: It should never be necessary for an importing tool to know the patch version number of the standard that the generating tool implemented.

In order to enable the backward-compatible extension of the SSP standard in minor releases and between minor releases, MAP SSP will make extensive use of the layered standard mechanism to introduce new features in a fully backward-compatible and optional way.

A layered standard defines extensions to the base SSP standard by specifying either standardized annotations, standardized extra files in SSP archives, and/or support for additional MIME types/file formats, as defined in Section 2.1. A layered standard can include a single or combined set of extension mechanisms from this set. The layered standard is thus considered to be layered on top of the definitions and extensions mechanisms provided by this base standard.

Layered standards can fall into three categories:

- Layered standards can be defined by third parties, making them third-party layered standards, without any representations by MAP SSP for their suitability or content, or even knowledge by MAP SSP about their existence.
- Layered standards can be defined/adopted and published by MAP SSP itself, making them MAP SSP layered standards.
- Finally, layered standards that have achieved enough adoption or importance to be included into the base standard set can be incorporated into a new minor release version of the base standard as an optional or mandatory appendix, making support for this layered standard optional or required for conformance with the newly published minor release version of the base standard.

2.3. Content addressing

All references between files using file formats defined in the SSP standard are expressed through URIs. Usually those references make use of relative URIs, where the base URI that those relative URIs are resolved against are specified in the SSP standard [*e.g. for SSDs, relative URIs to other content are usually resolved against the URI of the SSD, but can optionally also be resolved against the URI of referenced components, e.g. in order to reference a file inside a referenced FMU.*].

However the SSP syntax is not restricted to relative URIs, and allows both absolute URIs, and URIs of any schema to be used to identify and/or locate referenced content. Besides basic support for file-schema URIs, the set of schemas and transport mechanisms supported are up to the implementation.

This approach allows the uniform expression of dependencies, regardless of whether the SSP distribution is file-based, web-based or using a PLM system or other repository.

3. System Structure Package (SSP)

System Structure Package (file extension `.ssp`) files are specified to allow the packaging of System Structure Description (`*.ssd`) files together with related resources, like referenced FMUs, parameter files, etc.

System Structure Package files **MUST** be valid ZIP archives as specified in [ZIP635] with the following restrictions:

- All file entries **MUST** use either compression method 0 (stored) or 8 (deflated).
- Encryption **MUST NOT** be used.
- Splitting of ZIP archives into multiple files **MUST NOT** be used.
- The maximum value for the version needed to extract field (section 4.4.3 of the ZIP specification) **MUST NOT** be larger than version 2.0 for all entries in the archive.

For maximum portability, it is **RECOMMENDED** to keep all zip file entry names to the ASCII character set, and keep the language encoding flag (EFS), i.e. bit 11 of the general purpose field as specified in section 4.4.4 of the ZIP specification, set to zero. If use of a larger character set is needed, it is **RECOMMENDED** to use the UTF-8 encoding option, as specified in appendix D of the ZIP specification, by setting the language encoding flag (EFS) to 1 and encoding all filename and comment fields as UTF-8.

Use of other character sets and encodings is **NOT RECOMMENDED** and is likely to yield portability problems.

[It should be noted that some common implementations of ZIP archivers erroneously encode characters beyond the Unicode Basic Multilingual Plane (BMP), i.e. code point U+10000 and above, using UTF-8 encoded surrogate pairs, yielding the CESU-8 encoding, instead of correctly encoding those codepoints directly using UTF-8. It should also be noted that Unicode normalization issues that affect cross filesystem/OS compatibility might need to be addressed, since those issues are not addressed in the ZIP specification.]

The ZIP archive **MUST** contain an entry named `SystemStructure.ssd` at root level, containing a valid System Structure Description, as specified in Chapter 5.

Optionally the ZIP archive **MAY** contain multiple SSD file entries at root level, each with a different file name [e.g. `SystemStructure.ssd`, `VarA.ssd`, `VarB.ssd`]. This allows the bundling of multiple variants of a system structure definition referencing a similar set of packaged resources as one SSP. There **MUST** still be one SSD file named `SystemStructure.ssd` at the root of the ZIP archive which is deemed to be the default variant. Tools not supporting variant-containing SSPs **MUST** deal with the given SSP by ignoring all contained SSD files except for the `SystemStructure.ssd` default file.

If the ZIP archive contains multiple SSD file entries at the root level, the `name` attribute of each such system structure definition **MUST** be different from any of the other root level system structure definitions.

*[Tools **MAY** want to be prepared to handle SSP archives that violate the unique name requirement, as this was not present in earlier releases of SSP, and manually generated SSP archives may inadvertently violate this requirement.]*

Tools **SHOULD** use the `name` attribute of the root `SystemStructureDescription` element of the SSD files when presenting the system structure to the user, for example when selecting individual variant SSDs from an SSP.

The ZIP archive **MAY** contain additional entries with the prefix `resources/` which can be used to bundle resources referenced from the System Structure Description file(s) through relative URIs as specified in the sections below.

[Note: These additional entries may include additional files describing Parameter Values (`.ssv`), Parameter Mappings (`.ssm`) or Signal Dictionaries (`.ssb`). The names of these files, like all other additional files, are arbitrary and are independent of variant handling or the names of the referencing SSD files themselves. All stand-alone files are referenced by SSD files via (relative) URIs.]*

The ZIP archive **MAY** contain additional entries with the prefix `extra/` which can be used to store additional data and meta-data. In order to ensure uniqueness the extra files **SHOULD** be provided in sub-directories using a reverse domain name notation [cf. *Java package names or Apple UTIs*] of a domain that is controlled by the entity defining the semantics and content of the additional entries. The use of sub-directories beginning with `org.modelica` and `org.ssp-standard` is explicitly reserved for use by MAP SSP-defined layered standards (cf. Section 2.2), i.e. other uses **MUST NOT** use sub-directory names beginning with these prefixes.

It is explicitly allowed for tools and users other than the original creator of an SSP to modify/add/delete entries in the `extra/` prefix without affecting the validity of SSP in all other aspects. Specifically all validation or digital signature schemes used to protect SSP content **SHOULD** take the variability of extra file content into account. [*For example by having separate checksums/signatures for SSP core content and extra content, or not having signatures at all for extra content.*]

The ZIP archive **MAY** contain additional entries with the prefix `documentation/` which can be used to store documentation on the package contents. If documentation is provided an entry with the name `documentation/index.html` **MUST** be provided which should be a useful entry point for the contained documentation.

All other prefixes are currently reserved for future use.

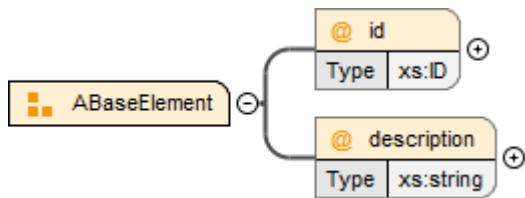
[*Note: The ZIP specification specifies clearly that the directory separator for ZIP entries is the forward slash regardless of operating system. Similarly the specification does not assign special meaning to directory parts named `.` or `..`, hence an entry named `./foo.txt` and an entry named `foo.txt` are distinct entries and specify separate files. Implementations are well-advised to take common vulnerabilities around ZIP handling, like e.g. the Zip Slip Vulnerability into account when processing SSP archives from untrusted sources.*]

4. Common Content (SSC)

Common Structures and Attributes that are used across all XML Schemas are defined in the SystemStructureCommon.xsd Schema, which is imported by all other XML Schemas. All Types and AttributeGroups live in the `http://ssp-standard.org/SSP1/SystemStructureCommon` namespace, nicknamed `ssc`.

4.1. Common Attributes

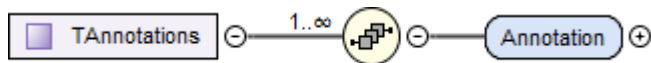
All XML elements that correspond to an entity of the system model will have the following set of common XML attributes, as defined in the `ssc:ABaseElement` attribute group:



Attribute	Description
id	This optional attribute gives the model entity a file-wide unique id which can be referenced from other entities or via URI fragment identifier.
description	This optional attribute gives a human readable longer description of the model entity, which can be shown to the user where appropriate.

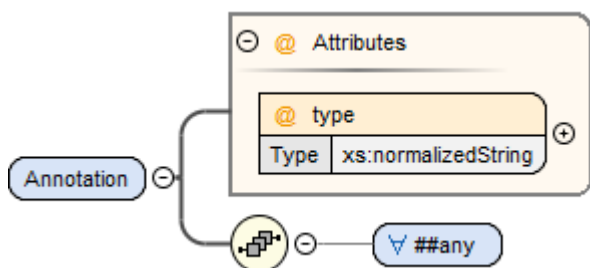
4.2. Common XML Child Elements

All XML elements that correspond to an entity of the system model will have the following set of common child elements:



Element	Description
Annotations	This optional element can be used to give additional information for any model entity. When it is present, it MUST contain 1 or more Annotation elements as specified below.

Each annotation is encapsulated in an Annotation element, with a required type attribute specifying the type of the annotation, and arbitrary XML content from arbitrary namespaces.



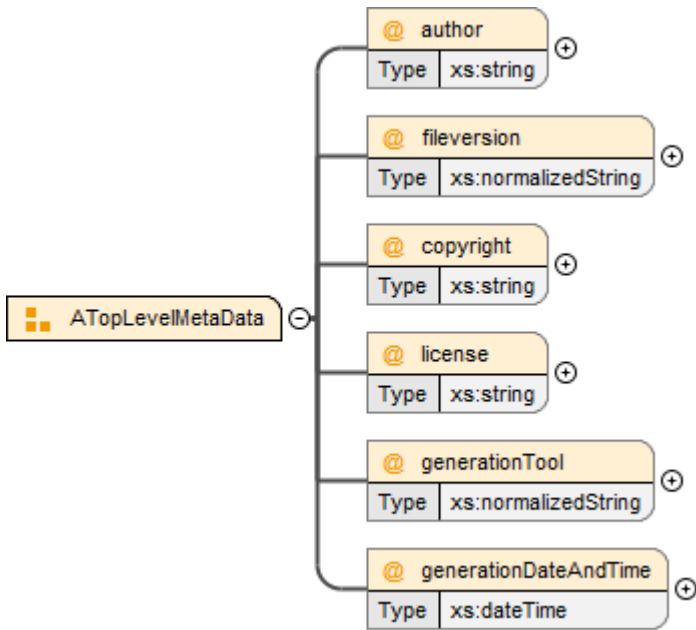
In order to ensure uniqueness the annotation type **SHOULD** be provided in reverse domain name notation [*cf. Java package names or Apple UTIs*] of a domain that is controlled by the entity defining the semantics and content of the annotation. For vendor-specific annotations this **SHOULD** be a domain controlled by the tool vendor. For MAP-SSP-defined annotations, this

MUST be a domain under the org.modelica or org.ssp-standard prefixes. Annotations that are not defined by MAP SSP **MUST NOT** use these two prefixes,

This mechanism can be used both for tool-specific annotations, as well as for layered standards (see Section 2.2) and other agreed-upon extensions, and thus provides a generic extension mechanism.

4.3. Top-Level Attributes

Top-level attributes are optional meta-data attributes common to all top-level container elements of all defined file formats.



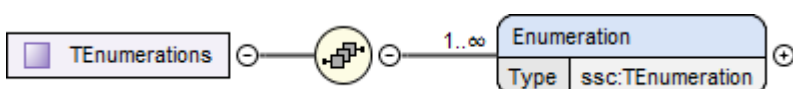
Attribute	Description
author	Optional attribute giving the name and/or organization of the author of the contents of this file.
fileversion	Optional attribute giving the version of the contents of this file.
copyright	Optional attribute giving information about copyrights of the contents of this file.
license	Optional attribute giving information about licensing of the contents of this file.
generationTool	Optional attribute giving information about the tool used to generate this file.
generationDateAndTime	Optional attribute giving the date and time this file was generated.

4.4. Top-Level XML Child Elements

Top-level elements of a defined file format may have the following set of common child elements.

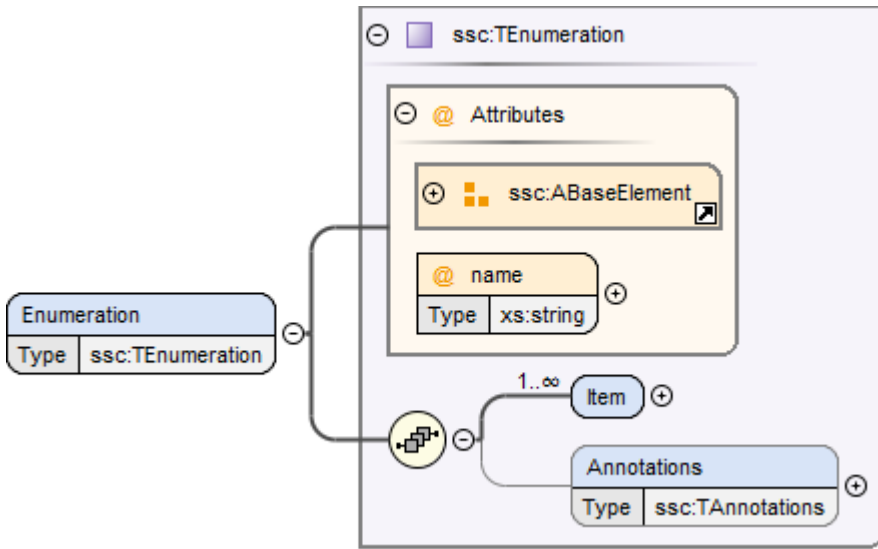
By design, the enumeration and unit definitions for each file are included in that file directly (i.e. enumeration and unit definitions are file scoped). This is intended to ensure the separate portability of individual files, with each file containing a self-consistent set of information. When processing information from multiple files, either from the same or separate system structures, it is up to the importing implementation to deal with any inconsistencies between files found.

4.4.1. Enumerations



This optional element **MUST** contain definitions for all enumerations referenced in a file.

[As a file-based interchange standard, the natural scope for units and enumerations is the file scope, so that files can be parsed and processed separately, without the need for cross-file references or scoped references with the possibilities of shadowing and ambiguities. Upon import tools are free to merge unit information across files or separate them between hierarchy layers as they see fit.]



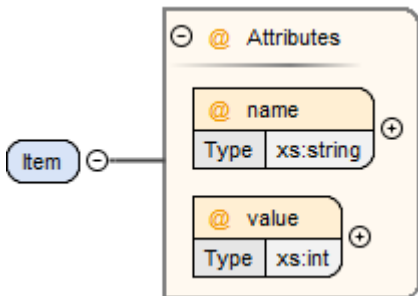
Each enumeration is defined through an Enumeration XML element:

Attribute	Description
name	This required attribute provides a name, which MUST be unique within the set of enumerations in a given file.

The following XML child elements are specified for the Enumeration element:

Element	Description
Item	One or more elements specifying the items of the enumeration.

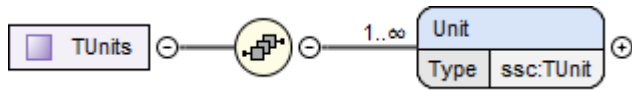
4.4.1.1. Item



For each item in the enumeration there is one Item XML element with the following attributes:

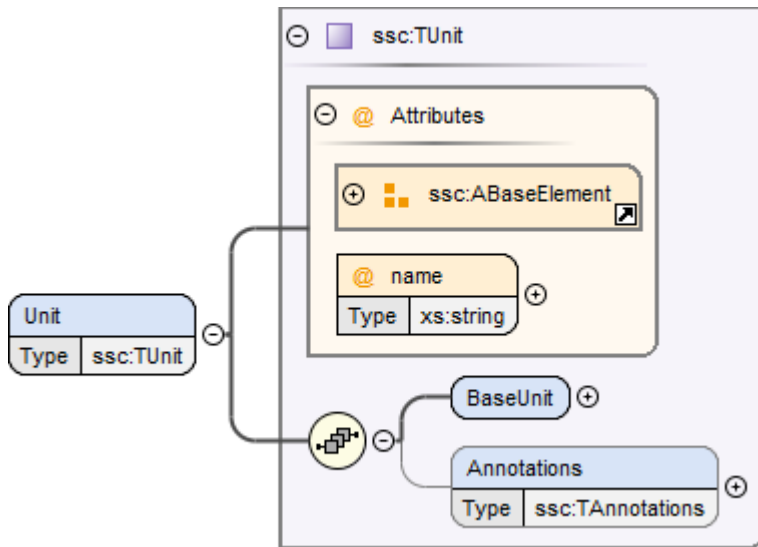
Attribute	Description
name	This required attribute provides a name for the enumeration item.
value	This required attribute provides a value for the enumeration item.

4.4.2. Units



This optional element **MUST** contain definitions for all units referenced in a file.

[As a file-based interchange standard, the natural scope for units and enumerations is the file scope, so that files can be parsed and processed separately, without the need for cross-file references or scoped references with the possibilities of shadowing and ambiguities. Upon import tools are free to merge unit information across files or separate them between hierarchy layers as they see fit.]



Each unit is defined through a Unit XML element:

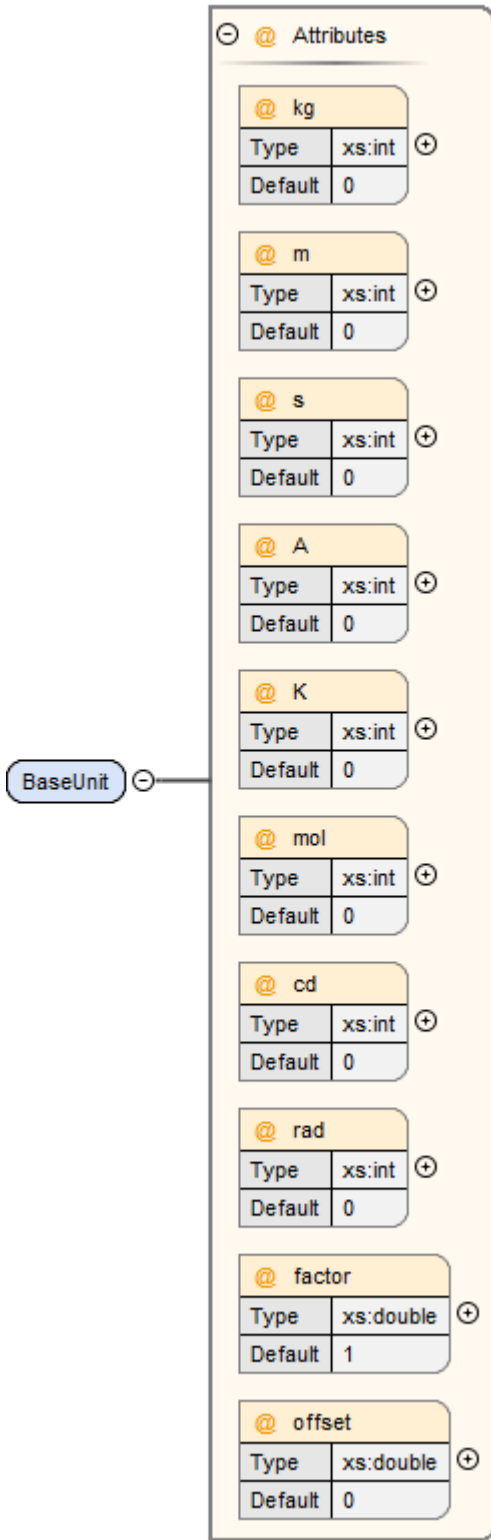
Attribute	Description
name	This required attribute provides a name, which MUST be unique within the set of units in a given file.

The following XML child elements are specified for the Unit element:

Element	Description
BaseUnit	Required element defining the base unit of the given unit in SI units, see below.

4.4.2.1. BaseUnit

This element defines the base unit of the given unit in SI units. This is completely aligned with the specification of base units in section 2.2.2 of the FMI 2.0 standard [FMI20].



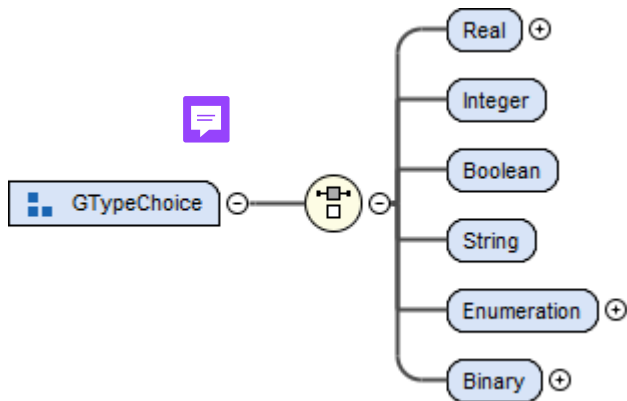
Attribute	Description
kg	Optional attribute specifying the exponent of SI base unit kg, defaults to 0.
m	Optional attribute specifying the exponent of SI base unit m, defaults to 0.
s	Optional attribute specifying the exponent of SI base unit s, defaults to 0.
A	Optional attribute specifying the exponent of SI base unit A, defaults to 0.
K	Optional attribute specifying the exponent of SI base unit K, defaults to 0.

Attribute	Description
mol	Optional attribute specifying the exponent of SI base unit mol, defaults to 0.
cd	Optional attribute specifying the exponent of SI base unit cd, defaults to 0.
rad	Optional attribute specifying the exponent of SI base unit rad, defaults to 0.
factor	Optional attribute specifying an optional factor, defaults to 1.
offset	Optional attribute specifying an optional offset, defaults to 0.

4.5. XML Element Groups

These XML element choices and sequences are common to multiple file formats. They are used inside elements to select one of multiple child elements, or provide common sequence content.

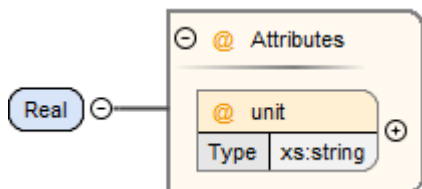
4.5.1. Type Choice



The following XML child elements denote the data type of a connector or dictionary entry. [*Note that in the case of connectors the use of a type element itself is optional, in the case of dictionary entries it is required*].

Element	Description
Real / Float64 / Float32 / Integer / Int8 / UInt8 / Int16 / UInt16 / Int32 / UInt32 / Int64 / UInt64 / Boolean / String / Enumeration / Binary	Exactly one of these elements MUST be present to specify the type of the element. See below for details.

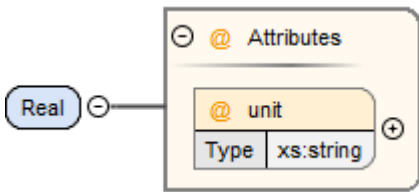
4.5.1.1. Real



This type specifies that the connector in question represents an IEEE754 double precision floating point number.

Attribute	Description
unit	<p>This optional attribute gives the name of a unit. The name MUST match the name of a Unit entry in the Units XML element of the top-level element of the file.</p> <p>If the attribute is not supplied, the unit is determined through default mechanisms: For FMU components, the unit of the underlying variable would be used, or no unit, if no unit is specified. For systems, the units of connected underlying connectors could be used if unambiguous.</p> <p>If a unit (or its absence) cannot be deduced unambiguously, the user should be informed of this error.</p> <p>Notwithstanding these mechanisms, unitless variables of type Real are supported.</p>

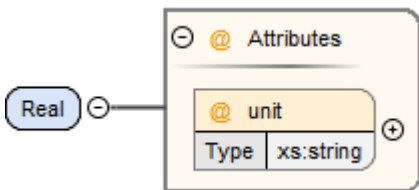
4.5.1.2. Float64



This type specifies that the connector in question represents an IEEE754 double precision floating point number.

Attribute	Description
unit	<p>This optional attribute gives the name of a unit. The name MUST match the name of a Unit entry in the Units XML element of the top-level element of the file.</p> <p>If the attribute is not supplied, the unit is determined through default mechanisms: For FMU components, the unit of the underlying variable would be used, or no unit, if no unit is specified. For systems, the units of connected underlying connectors could be used if unambiguous.</p> <p>If a unit (or its absence) cannot be deduced unambiguously, the user should be informed of this error.</p> <p>Notwithstanding these mechanisms, unitless variables of type Float64 are supported.</p>

4.5.1.3. Float32



This type specifies that the connector in question represents an IEEE754 single precision floating point number.

Attribute	Description
unit	<p>This optional attribute gives the name of a unit. The name MUST match the name of a Unit entry in the Units XML element of the top-level element of the file.</p> <p>If the attribute is not supplied, the unit is determined through default mechanisms: For FMU components, the unit of the underlying variable would be used, or no unit, if no unit is specified. For systems, the units of connected underlying connectors could be used if unambiguous.</p> <p>If a unit (or its absence) cannot be deduced unambiguously, the user should be informed of this error.</p> <p>Notwithstanding these mechanisms, unitless variables of type Float32 are supported.</p>

4.5.1.4. Integer

Integer

This type specifies that the connector in question represents a 32-bit signed integer number.

4.5.1.5. Int8

Integer

This type specifies that the connector in question represents a 8-bit signed integer number.

4.5.1.6. UInt8

Integer

This type specifies that the connector in question represents a 8-bit unsigned integer number.

4.5.1.7. Int16

Integer

This type specifies that the connector in question represents a 16-bit signed integer number.

4.5.1.8. UInt16

Integer

This type specifies that the connector in question represents a 16-bit unsigned integer number.

4.5.1.9. Int32

Integer

This type specifies that the connector in question represents a 32-bit signed integer number.

4.5.1.10. UInt32

Integer

This type specifies that the connector in question represents a 32-bit unsigned integer number.

4.5.1.11. Int64

Integer

This type specifies that the connector in question represents a 64-bit signed integer number.

4.5.1.12. UInt64

Integer

This type specifies that the connector in question represents a 64-bit unsigned integer number.

4.5.1.13. Boolean

Boolean

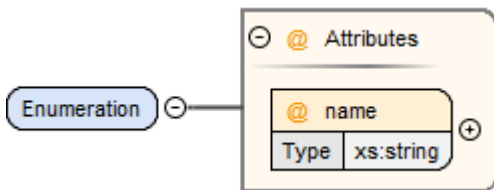
This type specifies that the connector in question represents a Boolean value.

4.5.1.14. String

String

This type specifies that the connector in question represents a zero-terminated UTF-8 encoded string.

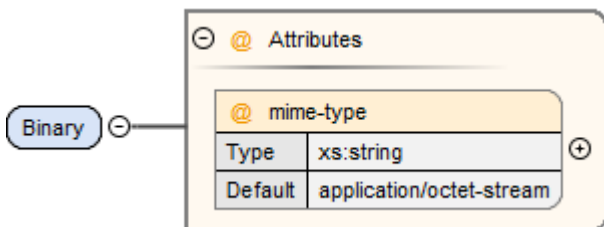
4.5.1.15. Enumeration



This type specifies that the connector in question represents an enumeration value, as specified by the enumeration definition. The underlying type of the connector is the same as for Integer.

Attribute	Description
name	This required attribute gives the name of an enumeration which references into the defined enumerations of a document. The name MUST match the name of an Enumeration entry in the Enumerations XML element of the top-level element of the file.

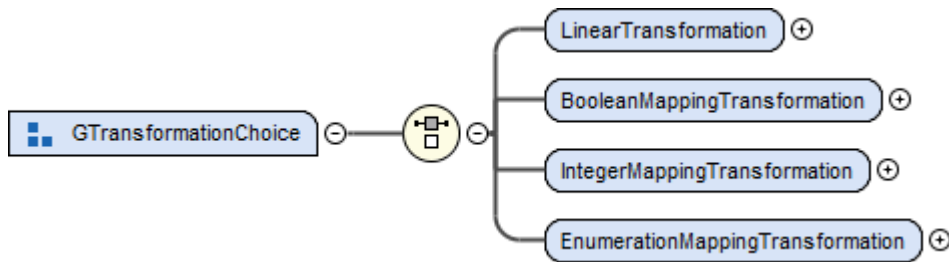
4.5.1.16. Binary



This type specifies that the connector in question represents a length-terminated binary data type, like the binary type defined for the FMI 3.0 standard, or substitute types like the binary type defined via the OSI Sensor Model Packaging specification [OSMP120].

Attribute	Description
mime-type	<p>This optional attribute specifies the MIME type of the underlying binary data, which defaults to the non-specific application/octet-stream type. This information CAN be used by the implementation to detect mismatches between connected binary connectors, or provide automatic means of conversion between different formats. It should be noted that the implementation is not required to provide this service, i.e. it remains the responsibility of the operator to ensure only compatible binary connectors are connected.</p> <p>The attribute value MUST be a valid MIME type as specified in RFC 2045; it CAN include additional arguments, etc., as specified in RFC 2045.</p>

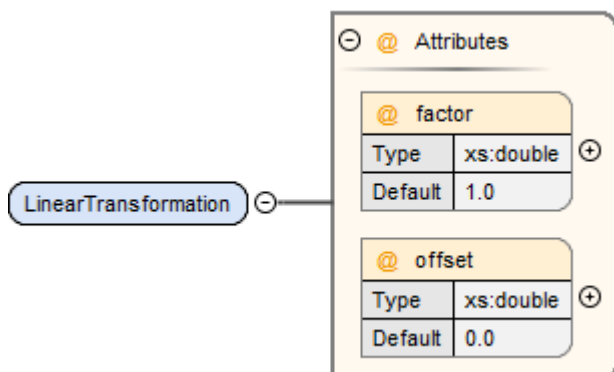
4.5.2. Transformation Choice



The following XML child elements specify a transformation to be applied to a value prior to its use in a connection or parameter mapping:

Element	Description
LinearTransformation	Specifies a linear transformation to be performed on the connection values.
BooleanMappingTransformation	Specifies a boolean mapping transformation to be performed on the connection values.
IntegerMappingTransformation	Specifies an integer mapping transformation to be performed on the connection values.
EnumerationMappingTransformation	Specifies an enumeration mapping transformation to be performed on the connection values.

4.5.2.1. LinearTransformation

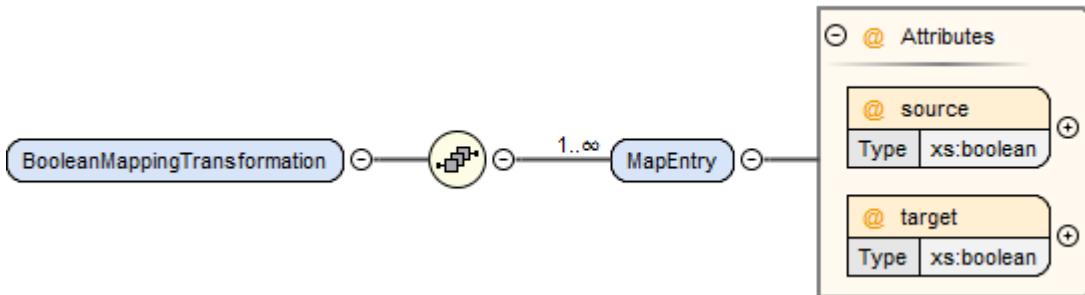


This element provides for a linear transformation of the source value to the target value, i.e. in the calculation $target = factor * source + offset$.

Note that conversions based on different units are performed, unless prevented by `suppressUnitConversion`, prior to the application of the linear transformation, i.e. the value of source is already converted to the target unit in the formula above. Linear transformations are only valid for connectors of Real, Float64 or Float32 type.

Attribute	Description
factor	This attribute specifies an optional factor value to use in a linear transformation. The default is 1.
offset	This attribute specifies an optional offset value to use in a transformation. The default is 0.

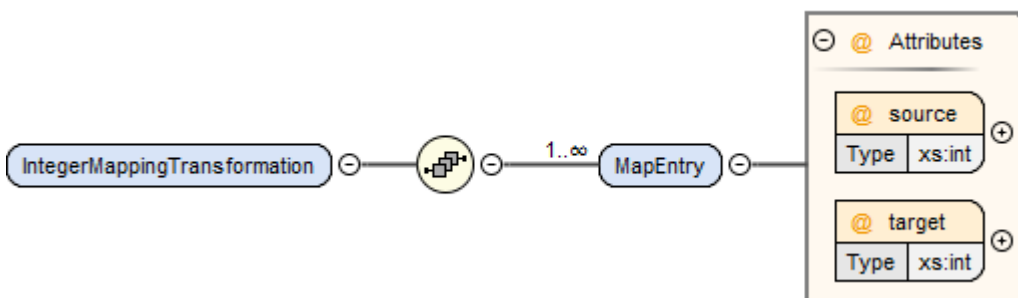
4.5.2.2. BooleanMappingTransformation



This element provides for a transformation of Boolean values based on a mapping table and is valid for connectors of Boolean type. Each mapping table entry is provided by a `MapEntry` element. Mapping entries **MUST** be unambiguous, i.e. for a given source value at a maximum one entry specifying that source value **MUST** be present. The mapping does not have to be complete, i.e. partial mappings **CAN** be specified. In that case values not mapped by a mapping entry are kept unchanged.

Attribute	Description
source	This attribute gives the source value that this entry applies to.
target	This attribute gives the value to use instead of the source value when applying it to the system or component.

4.5.2.3. IntegerMappingTransformation



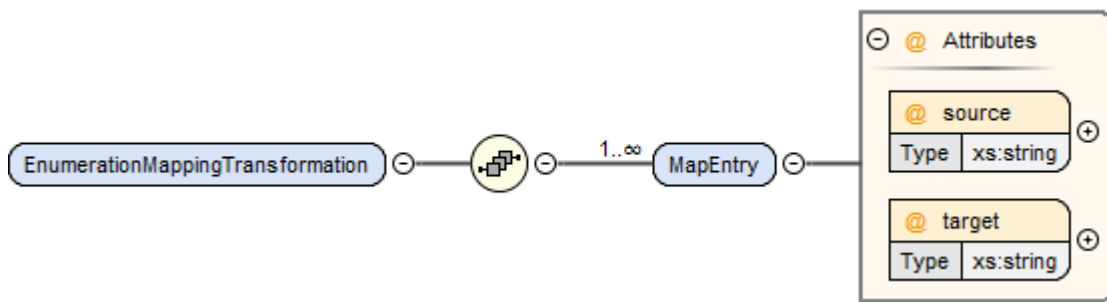
This element provides for a transformation of integer values based on a mapping table and is valid for connectors of all the integer types and Enumeration type. Each mapping table entry is provided by a `MapEntry` element. Mapping entries **MUST** be unambiguous, i.e. for a given source value at a maximum one entry specifying that source value **MUST** be present. The mapping does not have to be complete, i.e. partial mappings **CAN** be specified. In that case values not mapped by a mapping entry are kept unchanged.

When mapping to an Enumeration type, the target value **MUST** be a valid enumeration value for that type. When mapping from an Enumeration type, the source value **MUST** be a valid enumeration value for that type. This transformation can be applied between connectors of different Enumeration types, as long as all resulting target values are valid in the target Enumeration type.

The target values provided in transformation entries **MUST** be limited to the value space of the target connector. The source values provided in transformation entries **CAN** exceed the value space of the source connector. Such entries are ignored in the mapping process.

Attribute	Description
source	This attribute gives the source value that this entry applies to.
target	This attribute gives the value to use instead of the source value when applying it to the system or component.

4.5.2.4. EnumerationMappingTransformation

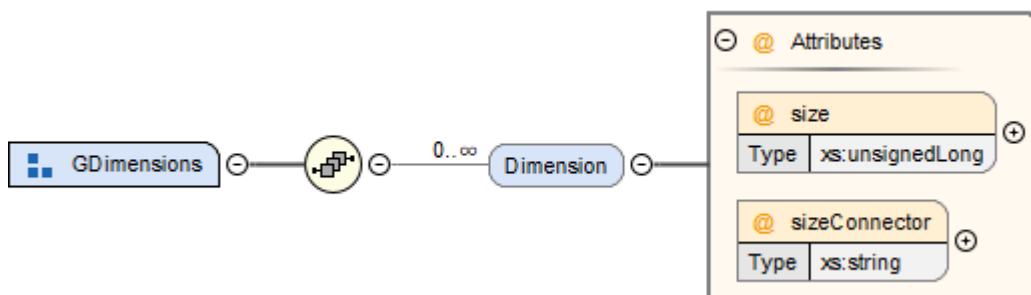


This element provides for a transformation of enumeration values based on a mapping table of their enumeration item names and is valid for connectors of Enumeration type. Each mapping table entry is provided by a MapEntry element. Mapping entries **MUST** be unambiguous, i.e. for a given source value at a maximum one entry specifying that source value **MUST** be present. The mapping does not have to be complete, i.e. partial mappings **CAN** be specified. In that case values not mapped by a mapping entry are kept unchanged.

When mapping to an Enumeration type, the target value **MUST** be a valid enumeration value for that type. When mapping from an Enumeration type, the source value **MUST** be a valid enumeration value for that type. This transformation can be applied between connectors of different Enumeration types, as long as all resulting target values are valid in the target Enumeration type.

Attribute	Description
source	This attribute gives the source value that this entry applies to.
target	This attribute gives the value to use instead of the source value when applying it to the system or component.

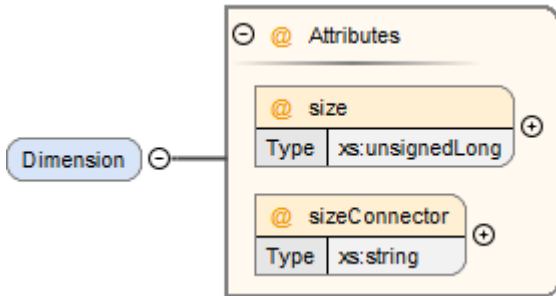
4.5.3. Dimension Sequence



The Dimension element is used to specify the dimensions of array connectors, signal dictionary entries, or parameter values.

Element	Description
Dimension	One or more instances of this element CAN be present to specify the dimensions of the containing model element. If no instances are present, the containing model element is scalar. See below for details.

4.5.3.1. Dimension



This element specifies one dimension of a potentially multi-dimensional array connector, signal dictionary entry, or parameter value (modeling element). If no dimension elements are present in a modeling element, it is a scalar modeling element. The number of dimension elements in a modeling element provides the dimensionality of the array.

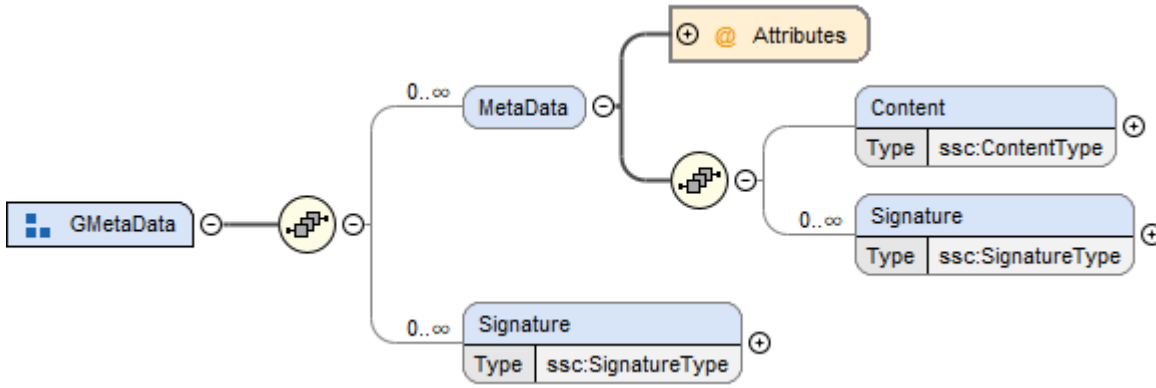
For connector elements, either the size or the sizeConnector attributes **CAN** be present on the element, indicating a fixed size, or a size that depends on the structural parameter or constant referenced by the sizeConnector attribute. If none of the attributes are present, then the size of the dimension is unspecified at the SSD level. It is considered an error if both attributes are present.

For signal dictionary and parameter value elements, only the size attribute can be used and therefore **MUST** be present on the element, indicating a fixed size. For those elements, it is considered an error if both attributes are present, or the size attribute is not present.

The following XML attributes are specified for the Dimension element:

Attribute	Description
size	This attribute gives the size of this dimension of the array as a fixed, unchangeable number.
sizeConnector	This attribute references another connector by name, that gives the size of this dimension of the array connector, e.g. a structural parameter or a constant of the underlying component that gives the dimension size.

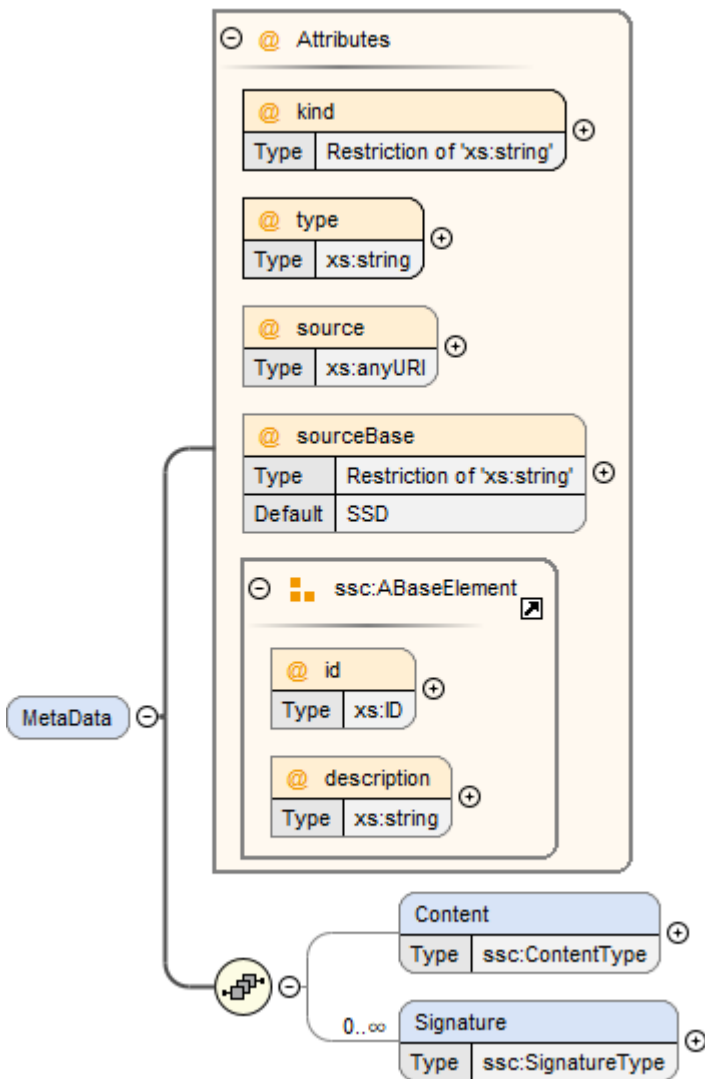
4.5.4. Metadata Sequence



The Metadata element allows the specification of additional meta data for a given model element. Multiple (or no) Metadata elements may be present in a given model element.

Element	Description
Metadata	One or more instances of this element CAN be present to specify meta data related to the containing model element. See below for details.

4.5.4.1. Metadata



This element specifies a source of meta data related to the containing model element.

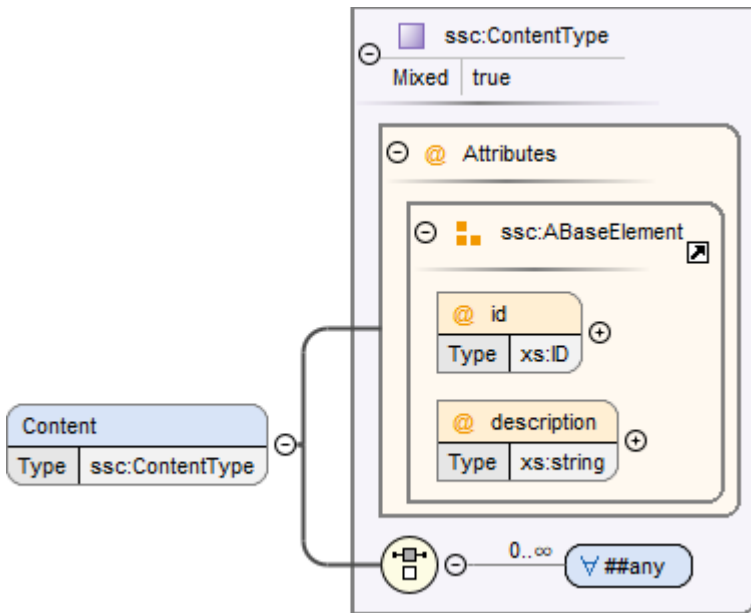
The Metadata element is structured by the following subordinated elements.

Element	Description
Content	An instance of this element CAN be present to contain inlined content of the model element meta data. If it is present, then the attribute <code>source</code> of the MetaData element MUST NOT be present. See below for details.
Signature	One or more instances of this element CAN be present to specify digital signature information on the meta data referenced by the enclosing MetaData element. It is left unspecified what types of signatures are used and/or available for now. See below for details.

The following XML attributes are specified for the MetaData element:

Attribute	Description
kind	This attribute indicates the kind of model element meta data that is referenced, i.e. what role it plays in relation to the model element being described. The kind can be <code>general</code> or <code>quality</code> , indicating general meta data or quality related meta data, respectively.
type	This mandatory attribute specifies the MIME type of the meta data, which does not have a default value. If no specific MIME type can be indicated, then the type <code>application/octet-stream</code> is to be used.
source	<p>Optional attribute indicating the source of the meta data as a URI (cf. RFC 3986). For purposes of the resolution of relative URIs the base URI is the URI of the SSD, if the <code>sourceBase</code> attribute is not specified or is specified as <code>SSD</code>, and the URI of the containing model element (e.g. component) if the <code>base</code> attribute is specified as <code>component</code>.</p> <p>This allows the specification of meta data sources that reside inside the component (for example an FMU) through relative URIs.</p> <p>If the <code>source</code> attribute is missing, the meta data MUST be provided inline as contents of a <code>Content</code> element, which MUST NOT be present otherwise.</p>
sourceBase	<p>Defines the base the source URI is resolved against: If the attribute is missing or is specified as <code>SSD</code>, the source is resolved against the URI of the SSD, if the attribute is specified as <code>component</code> the URI is resolved against the (resolved) URI of the model element (e.g. component) source.</p>

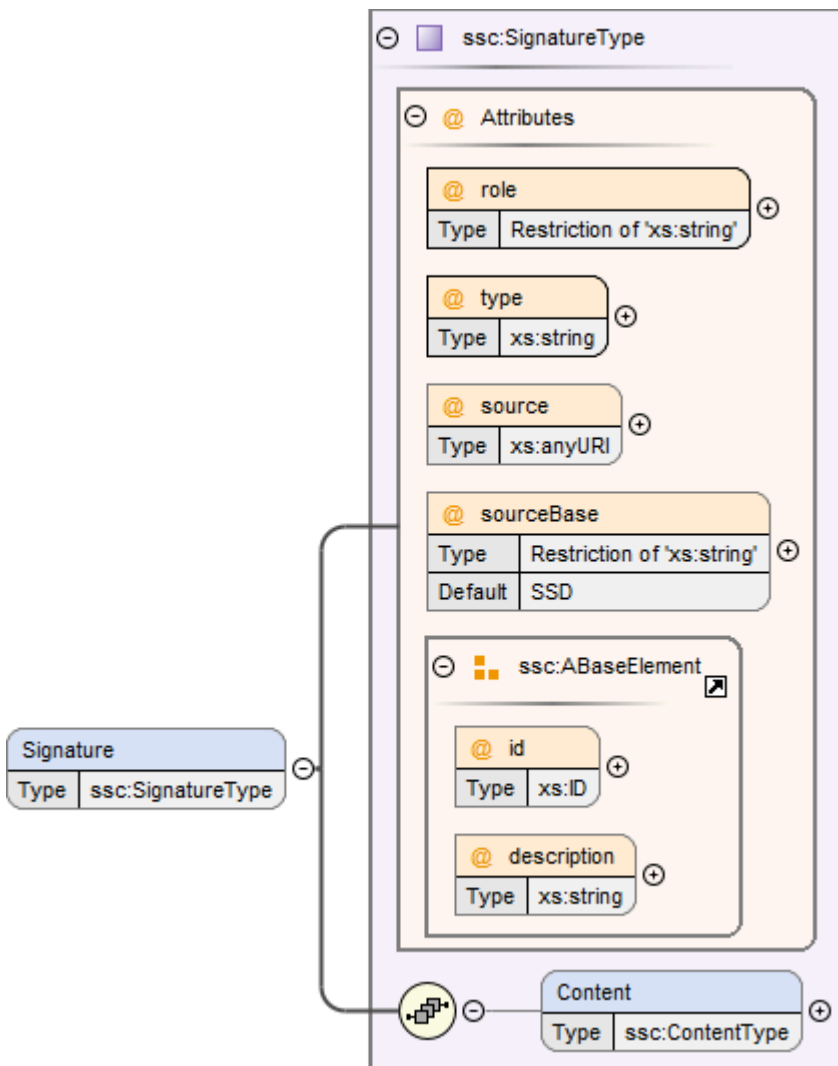
4.5.4.2. Content



This element specifies the inlined content of the model element meta data.

When this element is present, its contents **MUST** be an `srmd:SimulationResourceMetaData` element as specified by the SRMD schema of the SSP Traceability Specification, if the type attribute of the enclosing `MetaData` element is `application/x-srmd-meta-data`, or any other valid XML content if the type attribute references another MIME type. In that case there **SHOULD** be a layered specification that defines how embedding the content works for that MIME type.

4.5.4.3. Signature



This element specifies digital signature information on the data or meta data referenced by the enclosing element: If the Signature element is contained within a MetaData element, it refers to the meta data referenced by the MetaData element. If the Signature element is contained within any other element, it refers to the content of that element.

The Signature element is structured by the following subordinated elements.

Element	Description
Content	An instance of this element CAN be present to contain inlined content of the signature. If it is present, then the attribute <code>source</code> of the Signature element MUST NOT be present. See below for details.

The following XML attributes are specified for the Signature element:

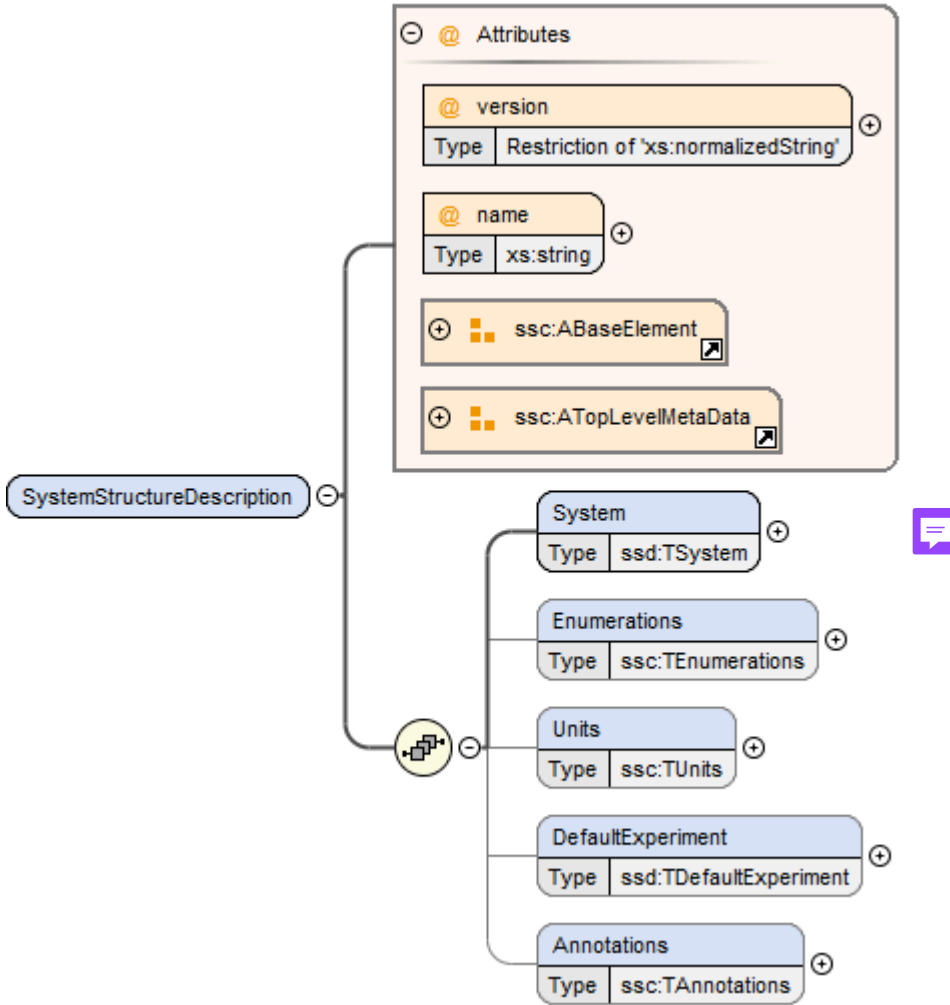
Attribute	Description
role	This mandatory attribute specifies the role this signature has in the overall process. It indicates whether the digital signature is intended to just convey the authenticity of the information (value <code>authenticity</code>), or whether a claim for suitability of the information for certain purposes is made (value <code>suitability</code>). In the latter case, the digital signature format should include detailed information about what suitability claims are being made.
type	This mandatory attribute specifies the MIME type of the signature, which does not have a default value. If no specific MIME type can be indicated, then the type <code>application/octet-stream</code> is to be used.
source	Optional attribute indicating the source of the signature as a URI (cf. RFC 3986). For purposes of the resolution of relative URIs the base URI is the URI of the SSD, if the <code>sourceBase</code> attribute is not specified or is specified as <code>SSD</code> , the URI of the containing model element (e.g. <code>component</code>) if the <code>base</code> attribute is specified as <code>component</code> , or the URI of the meta data source if the <code>sourceBase</code> attribute is specified as <code>metaData</code> . This allows the specification of signature sources that reside inside the component (for example an FMU), or the meta data through relative URIs. If the <code>source</code> attribute is missing, the signature MUST be provided inline as contents of a <code>Content</code> element, which MUST NOT be present otherwise.
sourceBase	Defines the base the source URI is resolved against: If the attribute is missing or is specified as <code>SSD</code> , the source is resolved against the URI of the SSD, if the attribute is specified as <code>component</code> the URI is resolved against the (resolved) URI of the model element (e.g. <code>component</code>) source, or if the attribute is specified as <code>metaData</code> the URI is resolved against the (resolved) URI of the meta data source. The value <code>metaData</code> is only valid if the Signature element is contained within a MetaData element.

5. System Structure Description (SSD)

A System Structure Description describes a nested hierarchy of interconnected (sub-)systems and atomic components.

A System Structure Description file (SSD, file extension .ssd) **MUST** be a well-formed XML 1.0 [XML10] file that conforms to the SystemStructureDescription XML Schema distributed as part of this standard. The file **MUST** use the UTF-8 encoding. All SSD-specific elements live in the `http://ssp-standard.org/SSP1/SystemStructureDescription` namespace, nicknamed `ssd`.

5.1. SystemStructureDescription



The root element of an SSD file **MUST** be a SystemStructureDescription element, which gives overall information about the system hierarchy described in this SSD file, including common meta-data, and acts as a bracket for the root system and its unit and enumeration definitions.

Attribute	Description
version	This required attribute specifies the version of this specification that the system description conforms to. Only major and minor version number are included, the patch version number MUST NOT be included in this attribute. For the current release this MUST be 1.0.
name	This required attribute provides a name, which can be used for purposes of presenting the system structure to the user, for example when selecting individual variant SSDs from an SSP.

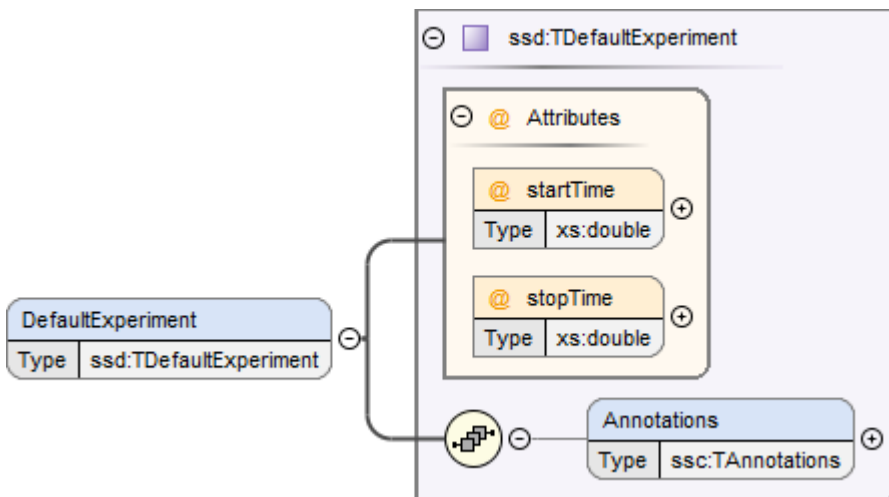
The following XML child elements are specified for the SystemStructureDescription element:

Element	Description
System	This required element specifies the root system of the model, see Section 5.3.
Enumerations	This optional element MUST contain definitions for all enumerations referenced in the system description file. See Section 4.4.1 for its definition.
Units	This optional element MUST contain definitions for all units referenced in the system description file. See Section 4.4.2 for its definition.
DefaultExperiment	This optional element MAY contain information of a default simulation setup that is supplied with the system definition for informational purposes, see description below.

The root system of the model is specified through the required System element, see Section 5.3.

Any enumerations and units referenced in the system description file **MUST** be provided through the optional Enumerations and Units elements, as described in Section 4.4.1 and Section 4.4.2 respectively.

5.1.1. Default Experiment



This element contains information of a default simulation setup that is supplied with the system definition for informational purposes.

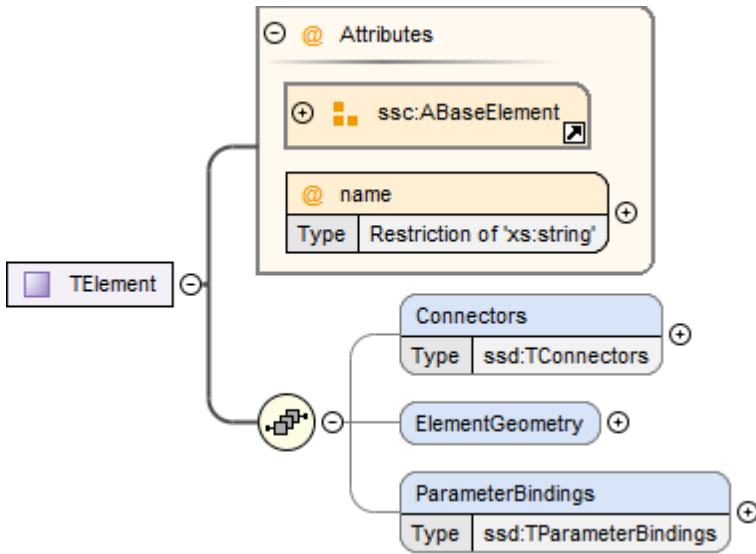
[Note that in contrast to FMI 2.0 only start and stop time are specified here, since values like step size or tolerance depend on the specific solver or master algorithms employed and are hence not specified in this global element. Additional solver or master algorithm specific information can be supplied through the annotation mechanism, or using a future layered standard.]

[The handling of systems comprising components with differing units for the independent variable depends on the implementation. It should be noted that since FMI 2.0 the unit of the independent variable for FMUs is clearly specified: It defaults to seconds, however other units can be specified by explicitly defining the independent variable. This standard does not specify additional measures to deal with differing independent variable units, but leaves this to the implementation.]

Attribute	Description
startTime	This optional attribute gives the start time of the simulation.
stopTime	This optional attribute gives the stop time of the simulation.

5.2. Common Model Element Type

System, Component and SignalDictionaryReference XML elements are subtypes of a common TElement base type, that contains attributes and XML elements common to all kinds of model elements:



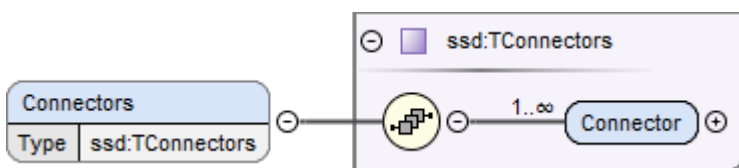
The following XML attributes are specified for the TElement type:

Attribute	Description
name	This required attribute gives the model element a name, which is used to identify the model element inside its parent system. The name MUST be unique within the directly enclosing parent system. The name MUST NOT be the empty string.

The following XML child elements are specified for the TElement type:

Element	Description
Connectors	This optional element specifies the set of connectors of this model element, which represent the interface of the model element to the outside world. See below for details.
ElementGeometry	This optional element defines the geometry information of the component. See below for details.
ParameterBindings	This optional element specifies the set of parameter bindings of this model element. See below for details.

5.2.1. Connectors

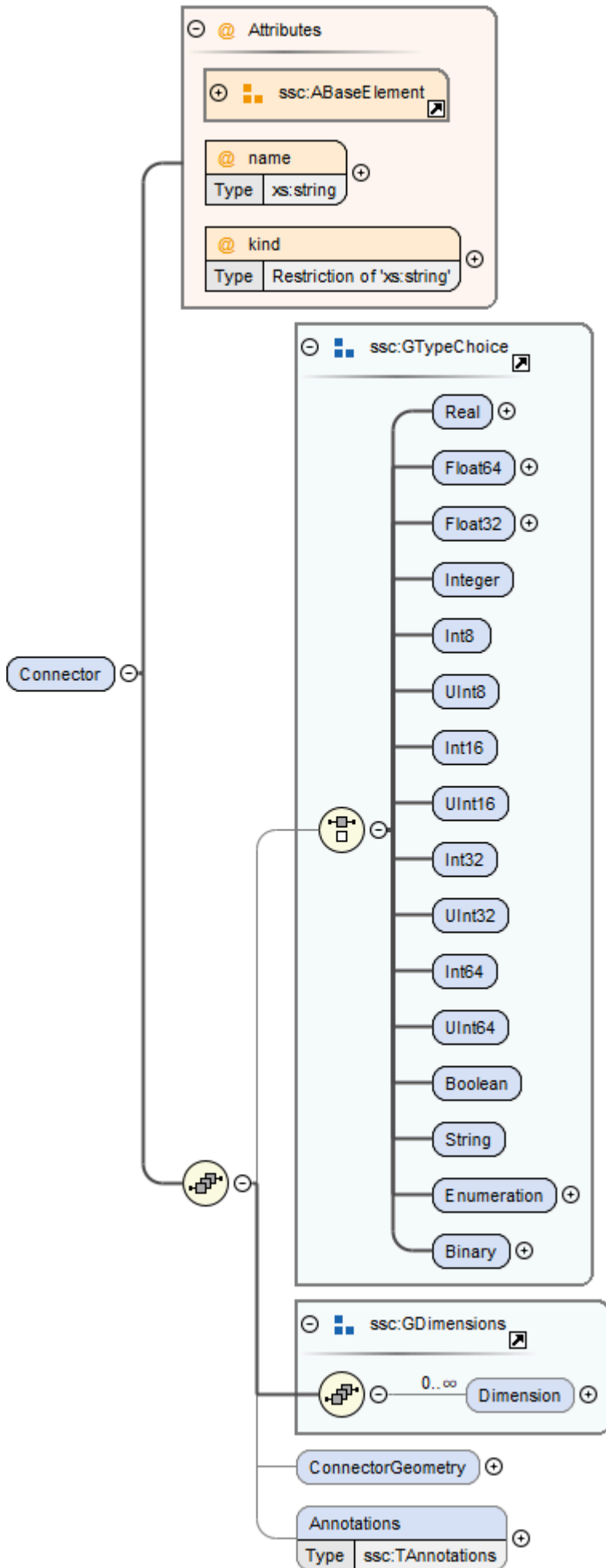


This optional element specifies the set of connectors of this model element, which represent the interface of the model element to the outside world. For components the set of connectors **MUST** match variables/ports of the underlying component implementation, e.g., for referenced FMI 2.0 FMUs, the name of a connector has to match the name attribute of the corresponding <ScalarVariable> element; for referenced FMUs that follow the OSI Sensor Model Packaging specification

[OSMP120], the name of a connector of type Binary has to match the name attribute of the corresponding <osmp:osmp-binary-variable>. For FMI 3.0 FMUs, the connector name has to match either the name of the corresponding variable element, or one of its <Alias> elements.

Names of variable elements of an FMU might follow the “Variable Naming Conventions” specification as defined by the FMI standard. Hence, several ScalarVariables might be grouped as a structure or an array. However, the name of a connector **MUST** match the name of a single <ScalarVariable>.

Note that there is no requirement that connectors have to be present for all variables/ports of an underlying component implementation. At least those connectors **MUST** be present which are referenced in connections inside the SSD. [*Note that connectors do not have to be referenced in connections. Unreferenced connectors will yield the behavior that is specified for the underlying component variables/ports, e.g. an unconnected FMU input variable will remain at its default value during the whole simulation. The same is true for variables/ports that are not referenced through a connector at all.*]



The following XML attributes are specified for the Connector element:

Attribute	Description
name	<p>This attribute gives the connector a name, which SHALL be unique within the given model element, and, for components, MUST match the name of a relevant variable/port in the underlying component implementation. In the case of referenced FMUs this MUST match the name of the relevant variable or alias in the referenced FMU.</p> <p>Note that there is no requirement that connectors have to be present for all variables/ports of an underlying component implementation. At least those connectors MUST be present which are referenced in connections inside the SSD.</p>
kind	<p>This attribute specifies the kind of the given connector, which indicates whether the connector is an input, an output, both (inout), unspecified, a local variable, a constant, a parameter, a calculated parameter (i.e. a parameter that is calculated by the component during initialization), or a structural parameter (i.e. a parameter that can be set during (re-)configuration mode).</p> <p>For components this MUST match the related kind of the underlying component implementation. For referenced FMUs it MUST match the combination of variability and causality:</p> <p>For FMI 2.0 and 3.0 this means that the causality of the variable MUST match the kind of the connector (with the kind inout not being valid for either FMI 3.0, 2.0, or 1.0).</p> <p>For FMI 1.0 this means that for connectors of kind input or output the causality of the variable MUST be input or output and the variability of the variable MUST be discrete or continuous (for outputs also constant and parameter are allowable). For connectors of kind parameter the causality of the FMI 1.0 variable MUST be input or internal and the variability MUST be parameter. For connectors of kind calculatedParameter the causality of the FMI 1.0 variable MUST be output and the variability MUST be parameter. For connectors of kind constant the causality of the FMI 1.0 variable MUST be output and the variability MUST be constant.</p> <p>Connectors of kind <code>local</code> are used to define variables of the model element. Such a variable is not intended to be used for connections. However, if it is connected, the semantics are same as for an <code>output</code>.</p> <p>For <code>SignalDictionaryReferences</code>, the kind of a given connector can additionally be <code>inout</code>, which indicates that the semantics of the connector are derived from the connections going to the connector. This can be used for example to allow a connector to function as both an input and output within the same <code>SignalDictionaryReference</code>.</p> <p>Connectors of kind <code>unspecified</code> are used to define connectors for which the flow of information is either not yet specified, or is determined at runtime, for example for acausal connections of Modelica models. Such connectors can be connected to any other connector under the rules of the underlying modeling language.</p>

The following XML child elements are specified for the Connector element:

Element	Description
Real / Float64 / Float32 / Integer / Int8 / UInt8 / Int16 / UInt16 / Int32 / UInt32 / Int64 / UInt64 / Boolean / String / Enumeration / Binary / Clock	Exactly one of these elements CAN be present to specify the type of the Connector. See Section 4.5.1 for details.
Dimension	One or more of these optional elements specify the connector array dimensions, making the connector an array connector. See Section 4.5.3 for details.
Clock	One or more of these optional elements associate the connector to a clock of the given name, which must be defined on the element that contains this connector.
ConnectorGeometry	This optional element defines the geometry information of the connector. See below for details.

The type of the Connector is identified by the presence of one of the XML child elements Real, Float64, Float32, Integer, Int8, UInt8, Int16, UInt16, Int32, UInt32, Int64, UInt64, Boolean, String, Enumeration, Binary, or Clock.

The dimensionality of the Connector is given by the presence of one or more Dimension elements.

The association of a connector to a clock is given by the presence of one or more Clock elements.

When Modelica models are represented in SSP, built-in input and output connectors shall be mapped as follows:

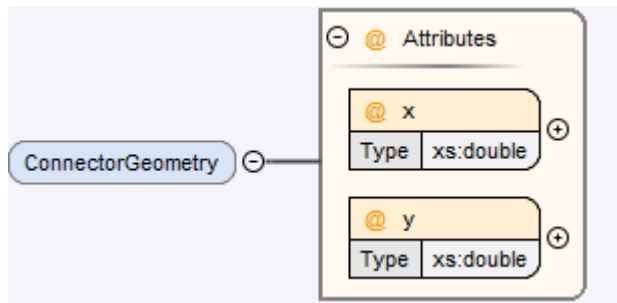
Modelica Type	SSP Type	SSP Kind
RealInput	ssc:Real	input
RealOutput	ssc:Real	output
IntegerInput	ssc:Integer	input
IntegerOutput	ssc:Integer	output
BooleanInput	ssc:Boolean	input
BooleanOutput	ssc:Boolean	output
StringInput	ssc:String	input
StringOutput	ssc:String	output

Modelica connectors of more advanced types are currently mapped in the following way:

- The connector type is ssc:Binary.
- The media type is `text/x-modelica` and the `path` parameter of the media type designates the path of the Modelica connector.
- Acausal Modelica connector types are mapped to connectors of kind unspecified.

[Note that the current opaque mapping of more advanced types to Binary connectors is a temporary solution, and a more detailed mapping may be provided in future versions of the standard supporting more complex data types.]

5.2.1.1. ConnectorGeometry



This optional XML element gives the geometry information of the connector. Note that x and y coordinates are in a normalized connector coordinate system, where 0,0 is the lower-left corner of the containing model element, and 1,1 is the upper-right corner of the model element, regardless of aspect ratio.

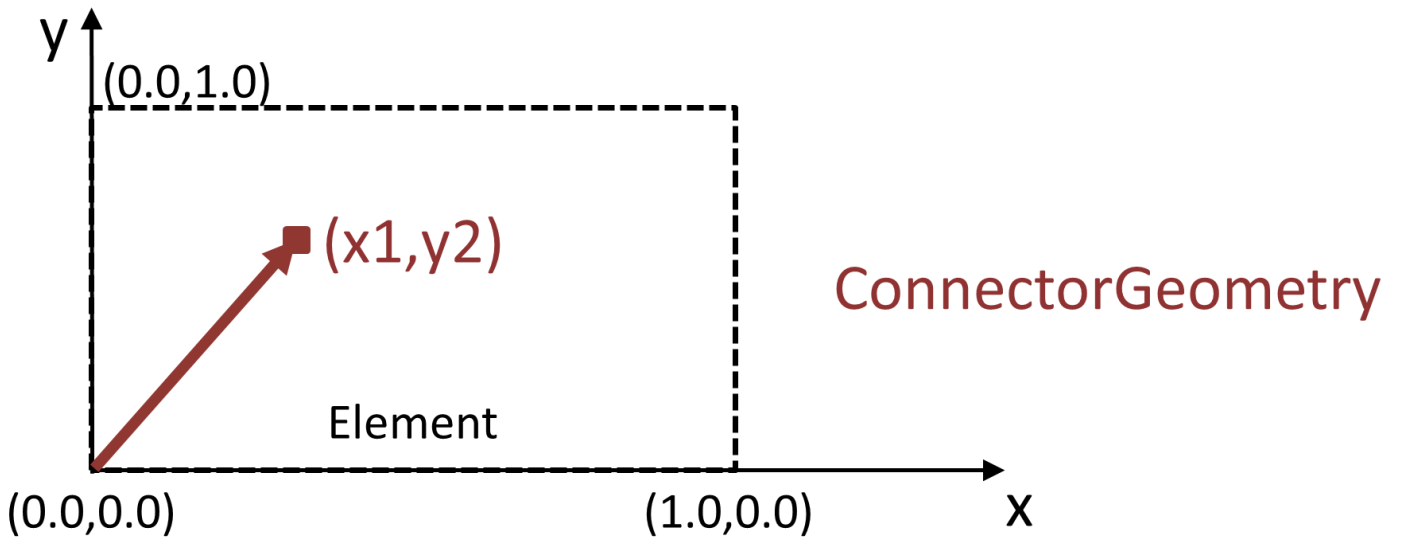
By default, the placement of connectors for a system's inside and outside views is identical. The connector coordinate system is just translated to different actual coordinate systems, namely the one determined by ElementGeometry for the outside view and the one determined by SystemGeometry for the inside view.

For systems, optionally, different placement of connectors for the inside view of the system can be specified with the systemInnerX and systemInnerY coordinates. This enables preserving the inside system layout when integrating a system in a system structure and avoiding unintended changes to the position of the connectors on the inside view of the system when making layout changes on the outside view and vice versa.

If defined, this ConnectorGeometry overrides any ConnectorGeometry of a System in a referenced SSD file or any port location defined by an FMU (as defined in the relevant FMI standards) for the x and y coordinates of the outside view. Any inside view is not overridden.

Attribute	Description
x	Required attribute giving the x coordinate of the connector inside the connector coordinate system.
y	Required attribute giving the y coordinate of the connector inside the connector coordinate system.
systemInnerX	Optional attribute giving a separate x coordinate of the connector for the inside view of a system.
systemInnerY	Optional attribute giving a separate y coordinate of the connector for the inside view of a system.

[Graphical example for a ConnectorGeometry:



]

5.2.2. ElementGeometry

Attributes

- @ x1
Type xs:double
- @ y1
Type xs:double
- @ x2
Type xs:double
- @ y2
Type xs:double
- @ rotation
Type xs:double
Default 0.0
- @ iconSource
Type xs:anyURI
- @ iconRotation
Type xs:double
Default 0.0
- @ iconFlip
Type xs:boolean
Default false
- @ iconFixedAspectRatio
Type xs:boolean
Default false

ElementGeometry

This optional XML element defines the geometry information of the model element, where (x_1, y_1) and (x_2, y_2) define the positions of the lower-left and upper-right corners of the model element in the coordinate system of its parent system. If $x_1 > x_2$ this indicates horizontal flipping, $y_1 > y_2$ indicates vertical flipping.

The optional attribute rotation (in degrees) defines an additional rotation (applied after flipping), where positive numbers indicate a counter clockwise rotation.

[Sometimes such a counter clockwise orientation is also called a left rotation ($x \rightarrow y$), with the coordinate system orientation: $x \rightarrow$ right, $y \rightarrow$ up]

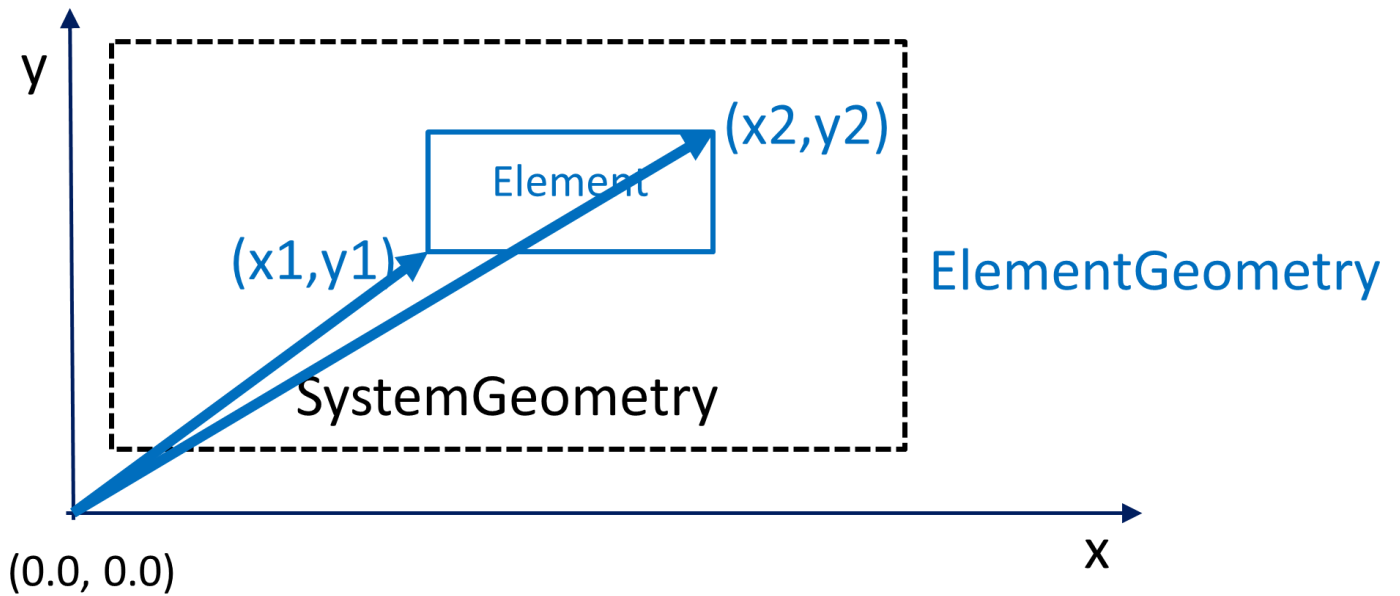
The optional attribute iconSource defines an icon URI with the same semantics as for the source attribute of the Component element. If defined, this icon overrides any icon that may be defined in an .fmu file (as defined in the relevant FMI standards). It is **RECOMMENDED** that implementations that support graphical presentation support at least PNG and SVG file formats for the icon.

The optional attribute iconRotation defines the rotation (in degrees) of the icon. The optional attribute iconFixedAspectRatio defines whether the icon shall be fit into the extent defined by (x_1, y_1) , (x_2, y_2) and iconRotation with fixed aspect ratio. The optional attribute iconFlip defines whether any flipping indicated by (x_1, y_1) , (x_2, y_2) shall be applied to the icon graphics, too.

[If no explicit icon is given, the icon used by the tool to represent the system should be rotated accordingly.]

Attribute	Description
x1	Required attribute giving the x coordinate of the lower left corner of the model element inside the coordinate system of its parent system.
y1	Required attribute giving the y coordinate of the lower left corner of the model element inside the coordinate system of its parent system.
x2	Required attribute giving the x coordinate of the upper right corner of the model element inside the coordinate system of its parent system.
y2	Required attribute giving the y coordinate of the upper right corner of the model element inside the coordinate system of its parent system.
rotation	Optional attribute defines an additional rotation in degrees that is to be applied after any flipping, where positive numbers indicate left rotation ($x \rightarrow y$).
iconSource	Optional attribute defines an icon URI with the same semantics as for the source attribute of the Component element. If defined, this icon overrides any icon that may be defined in an .fmu file (as specified in the relevant FMI standards). It is RECOMMENDED that implementations that support graphical presentation support at least PNG and SVG file formats for the icon.
iconRotation	Optional attribute defines the rotation (in degrees) of the icon, where positive numbers indicate left rotation ($x \rightarrow y$).
iconFlip	Optional attribute defines whether any flipping indicated by (x_1, y_1) , (x_2, y_2) shall be applied to the icon graphics, too, or not.
iconFixedAspectRatio	Optional attribute defines whether the icon shall be fit into the extent defined by (x_1, y_1) , (x_2, y_2) with a fixed aspect ratio, or without keeping the aspect ratio fixed.

[Graphical example for an ElementGeometry:



]

[The next examples show the effects of attributes of the ElementGeometry on the visual representation of a reference element:

Non-transformed reference (icon fills rectangle, left 2 inputs, right 1 output)



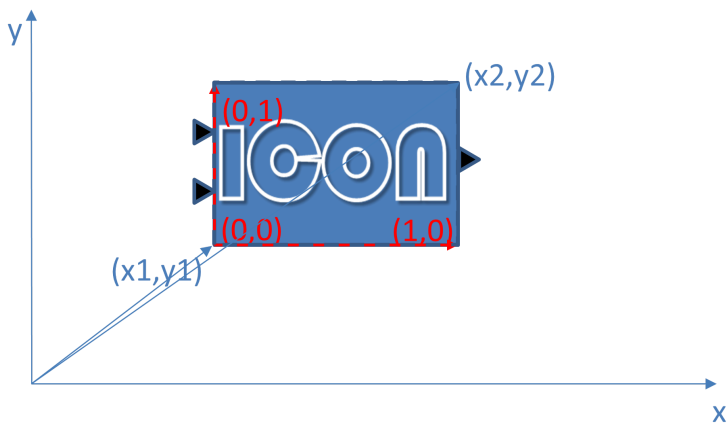
Coordinate systems:

Red: ConnectorGeometry

Blue: ElementGeometry

Example 1: No flip ($x_1 < x_2$, $y_1 < y_2$), rotation=0

iconRotation=0, iconFixedAspectRatio=true, iconFlip=IGNORED (relevant only if element is flipped)



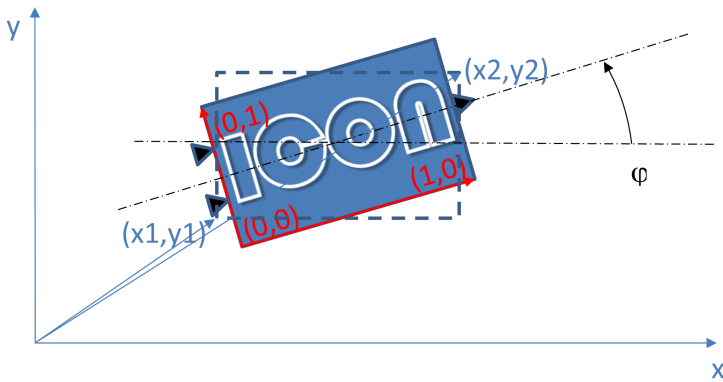
Example 2: No flip ($x_1 < x_2$, $y_1 < y_2$), rotation=0

iconRotation=0, iconFixedAspectRatio=false, iconFlip=IGNORED



-
-

Example 3: No flip ($x_1 < x_2, y_1 < y_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=**true**, iconFlip=**IGNORED**

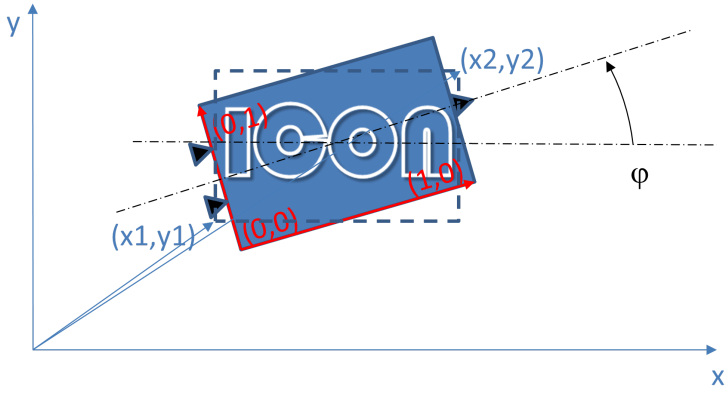


Example 4: No flip ($x_1 < x_2, y_1 < y_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=**false**, iconFlip=**IGNORED**



-
-

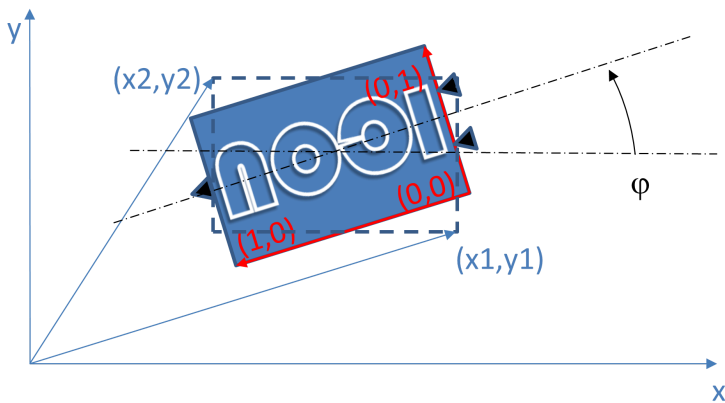
Example 5: No flip ($x_1 < x_2, y_1 < y_2$), rotation= ϕ
 iconRotation=**0**, iconFixedAspectRatio=**true**, iconFlip=**IGNORED**



Example 6: No flip ($x_1 < x_2$, $y_1 < y_2$), rotation= ϕ
 iconRotation= 0 , iconFixedAspectRatio=**false**, iconFlip=**IGNORED**



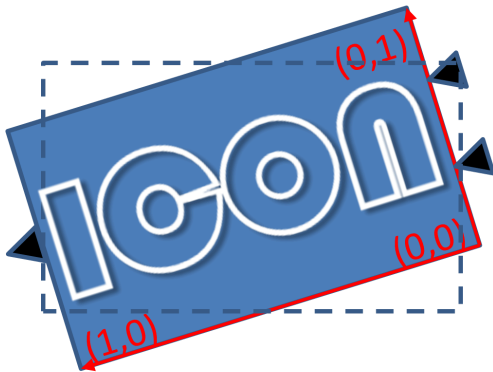
-
 -
 Example 7: Horizontal flip ($x_1 > x_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=**true**, iconFlip=**true**



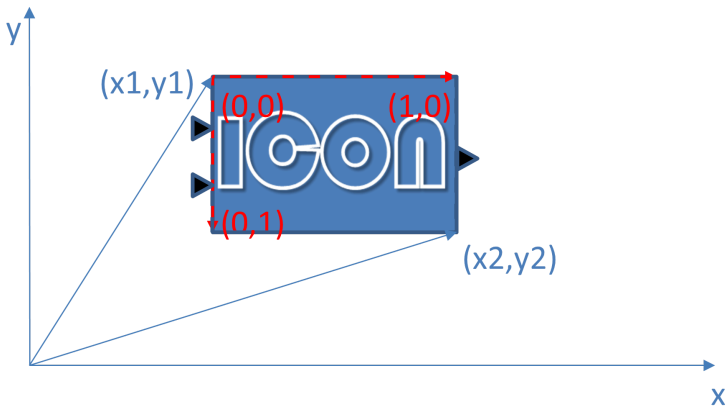
Example 8: Horizontal flip ($x_1 > x_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=**false**, iconFlip=**false**



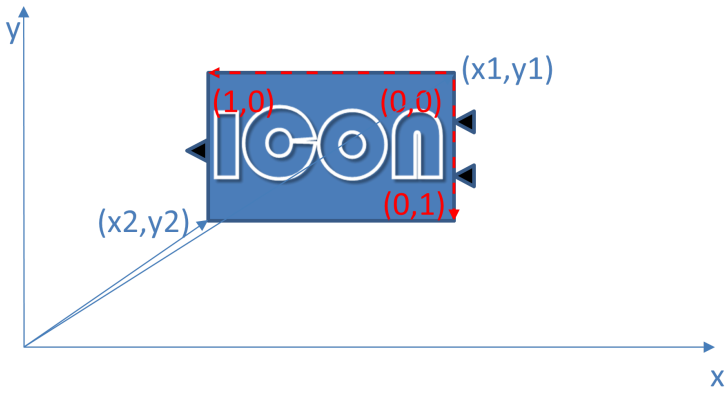
Example 9: Horizontal flip ($x_1 > x_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=**true**, iconFlip=**false**



Example 10: Vertical flip ($y_1 > y_2$), rotation= 0
 iconRotation= 0 , iconFixedAspectRatio=**true**, iconFlip=**false**



Example 11: Horizontal and vertical flip ($x_1 > x_2, y_1 > y_2$), rotation= 0
 iconRotation= 0 , iconFixedAspectRatio=**true**, iconFlip=**false**

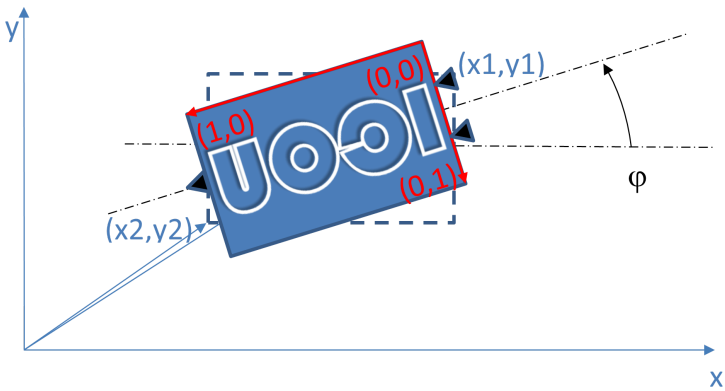


Example 12: Horizontal and vertical flip ($x_1 > x_2$, $y_1 > y_2$), *rotation=0
 iconRotation=0, iconFixedAspectRatio=true, iconFlip=true



-
-

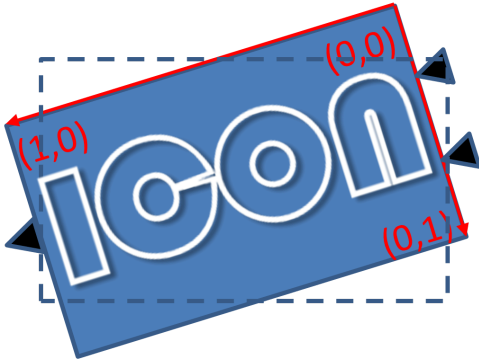
Example 13: Horizontal and vertical flip ($x_1 > x_2$, $y_1 > y_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=true, iconFlip=true



Example 14: Horizontal and vertical flip ($x_1 > x_2$, $y_1 > y_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=false, iconFlip=true

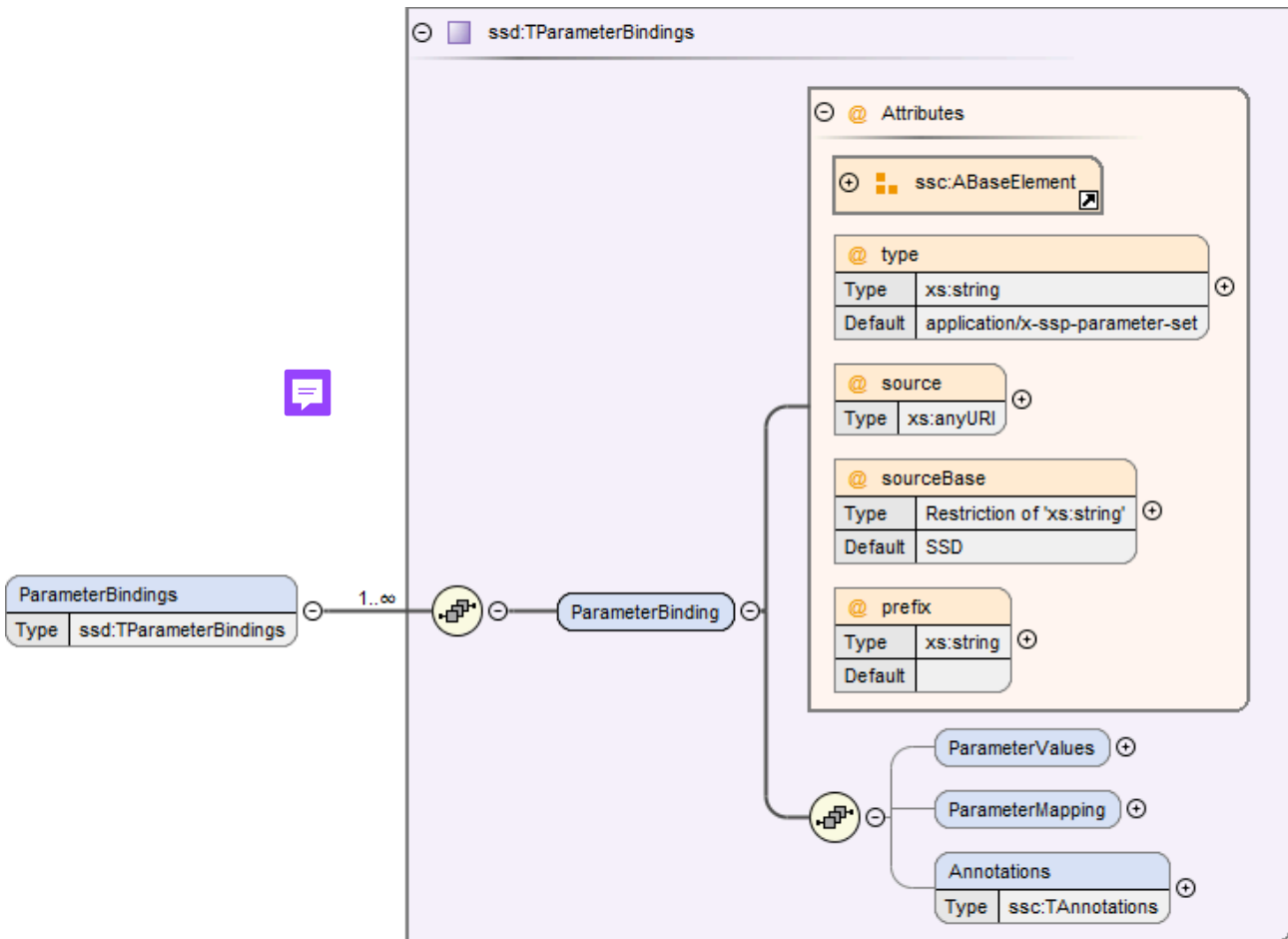


Example 15: Horizontal and vertical flip ($x_1 > x_2$, $y_1 > y_2$), rotation= ϕ
 iconRotation= ϕ , iconFixedAspectRatio=**true**, iconFlip=**false**



]

5.2.3. ParameterBindings



The ParameterBindings element provides the parameter bindings for a component or system, where each binding is specified in a ParameterBinding element. A parameter binding applies a set of parameter values (a parameter set), supplied by a parameter source (for example a parameter file) to parametrize a component or system.

For FMU components this allows the parametrization of the FMU’s parameters, structural parameters, and start values of other variables. For systems this allows the parametrization of complete (sub-)hierarchies of sub-systems and components using a hierarchical naming scheme.

When no parameter mapping is specified as part of the binding, then all the parameter values provided by the parameter source are applied using their original names. If a parameter matching this name is found in the system, the parameter value is applied. Otherwise that parameter value is ignored.

When a parameter mapping is specified as part of the binding, then only the mapped parameter values are applied, using their mapped-to names. Non-mapped parameter values are not applied in this case.

For FMU components parameter values are applied to FMU variables based on the variables' names in the FMU, i.e. it is **not required** (but allowed) that those variables are referenced in connectors in the system description.

For systems parameter values are applied using the hierarchical names of parameters or other variables in the system.

The hierarchical names of the parameters or other variables of a system are formed in the following way:

- Any variables of the system exposed through connectors of the system have the name of the connector as their name.
- For all elements of the system, the hierarchical names of the variables of those elements are formed by prepending the element name and a dot to the hierarchical names of the variables in that element.

[For example for a system A containing a system B which contains an exposed parameter named SP1 and an element C with a parameter P2, the hierarchical names of the parameters in system A are B.SP1 and B.C.P2 respectively. The hierarchical name of those parameters inside system B are SP1 and C.P2 respectively, and the hierarchical name of P2 inside element C is just P2.

Therefore a parameter binding on element C shall reference the parameter P2 using its local name P2, not the hierarchical name C.P2, which would be valid for a parameter binding on system B.]

Note that the hierarchical names of parameters or other variables do not have to be unique: If two or more variables end up with the same hierarchical name (due to so-called punning), then any parameter values being applied to that name **MUST** be applied to all of them. If this is not wanted, then it is up to the generating implementation to ensure that no punning occurs, through proper choice of system and element names.

[For example, for a system A containing a system B with component C and variable D, and system A also containing a component called B.C and variable D, both variables will have the hierarchical name A.B.C.D. If this is not wanted, then proper care should be taken in naming component B.C and system B/component C in non-conflicting ways. The standard allows such punning, because the ability to have a . in the name of systems or components allows for example the replacement of a monolithic component with a system of components, or vice-versa, while keeping parameter names identical.]

More than one ParameterBinding can be supplied. In this case all of the parameters found will be used to parametrize the component, with parameter values in ParameterBinding sources appearing at a succeeding position in the element order taking priority over prior sources at the same hierarchy level, should a parameter be included in more than one ParameterBinding source.

When ParameterBinding sources on multiple levels of the hierarchy supply values for the same parameter, bindings at a higher hierarchy level take precedence over lower levels, i.e. bindings at a system level take precedence over bindings at a sub-system or component level.

Parameter bindings for FMU components can be used to set any initial values in the FMU which are legal to change. It is assumed that the parameterization is applied prior to initializing for FMI 1.0, or before entering initialization mode for FMI 2.0/3.0. For structural parameters it is assumed that the parameterization is applied in configuration mode for FMI 3.0.

This means that variables eligible for parameterization are those with:

- either causality = "input" or a start value for FMI 1.0
- variability != "constant" and initial = "exact" or "approx" for **FMI 2.0**

All kinds of system connectors can be parameterized. In case the system level connectors are connected to FMU components, the parameterization **MUST** be compatible with the variable in the connected FMU.

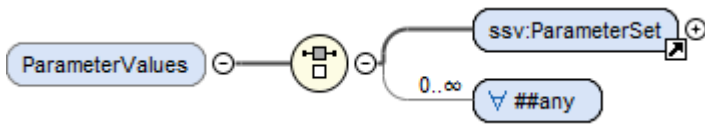
Parameter bindings that apply to a component that references another SSD/SSP are handled as if the top-level system of the SSD/SSP was present in the enclosing system instead of the component with one special case: Any parameter bindings in the component are treated as if they were present in the top-level system of the SSP/SSD after all parameter bindings of the system. Therefore they take priority over any of the existing parameter bindings (for parameters with identical names).

Attribute	Description
type	Optional attribute giving the MIME type of the parameter source, which defaults to application/x-ssp-parameter-set to indicate the SSP parameter set file format. No further types are currently defined, but can of course be added at a later date, for pre-existing parameter file formats, like CDF, etc.
source	Optional attribute indicating the source of the parameters as a URI (cf. RFC 3986). For purposes of the resolution of relative URIs the base URI is the URI of the SSD, if the sourceBase attribute is not specified or is specified as SSD, and the URI of the referenced component if the base attribute is specified as component. This allows the specification of parameter sources that reside inside the component (for example an FMU) through relative URIs. If the source attribute is missing, the parameter set MUST be provided inline as contents of a ParameterValues element, which MUST NOT be present otherwise.
sourceBase	Defines the base the source URI is resolved against: If the attribute is missing or is specified as SSD, the source is resolved against the URI of the SSD, if the attribute is specified as component the URI is resolved against the (resolved) URI of the component source.
prefix	Defines the optional prefix for name resolution and mapping purposes for this binding. If this attribute is empty or not supplied no prefix is used for name resolution and mapping, otherwise the specified prefix is prepended to all names in the parameter source prior to processing the normal name resolution or name mapping rules. This allows the user to apply a parameter set normally intended for a component (and thus containing bare parameter names) at a system level targeted to one element of the system by supplying the name of the element plus a dot as a prefix on the binding, thus causing all parameter names in the parameter set to be treated as if they were specified with proper hierarchical names.

The following XML child elements are specified for the ParameterBinding element:

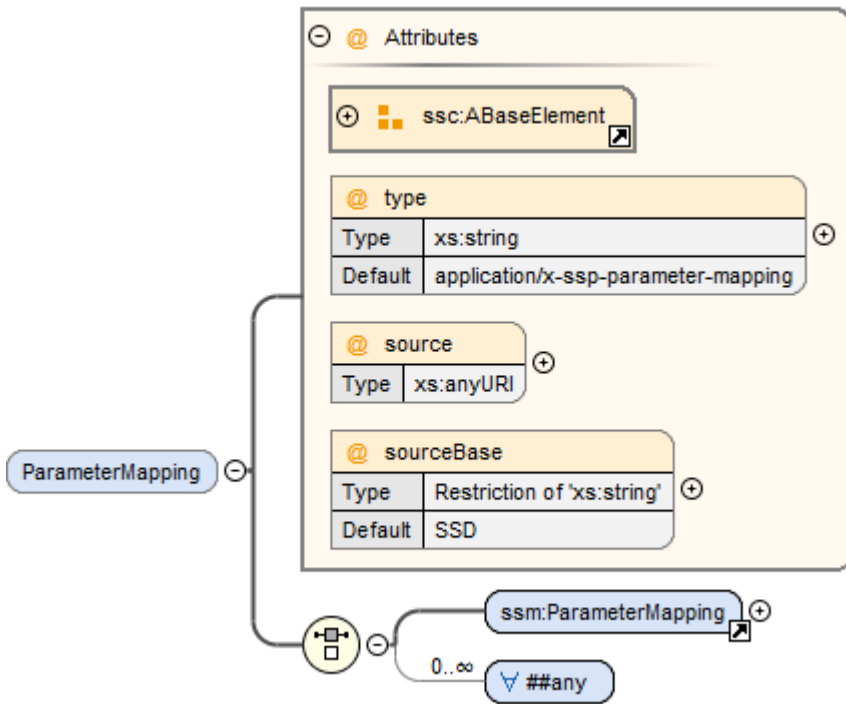
Element	Description
ParameterValues	This optional element can be used to provide parameter values inline to the parameter binding, in which case the source attribute of the ParameterBinding element MUST be empty.
ParameterMapping	This optional element provides an optional parameter mapping, which specifies how the parameter names and values provided in the parameter source are to be mapped to the parameters of the component or system in question. If no mapping is supplied, the parameter names of the parameter source are used as is for name matching against the names of parameters in the component or system and the values of the parameter source are not transformed further before being applied. See below for details.

5.2.3.1. ParameterValues



When this element is present, its contents **MUST** be an ssv:ParameterSet element as specified by the SystemStructureParameterValues schema, if the type attribute of the enclosing ParameterBinding element is application/x-ssp-parameter-set, or any other valid XML content if the type attribute references another MIME type. In that case there **SHOULD** be a layered specification that defines how embedding the content works for that MIME type.

5.2.3.2. ParameterMapping



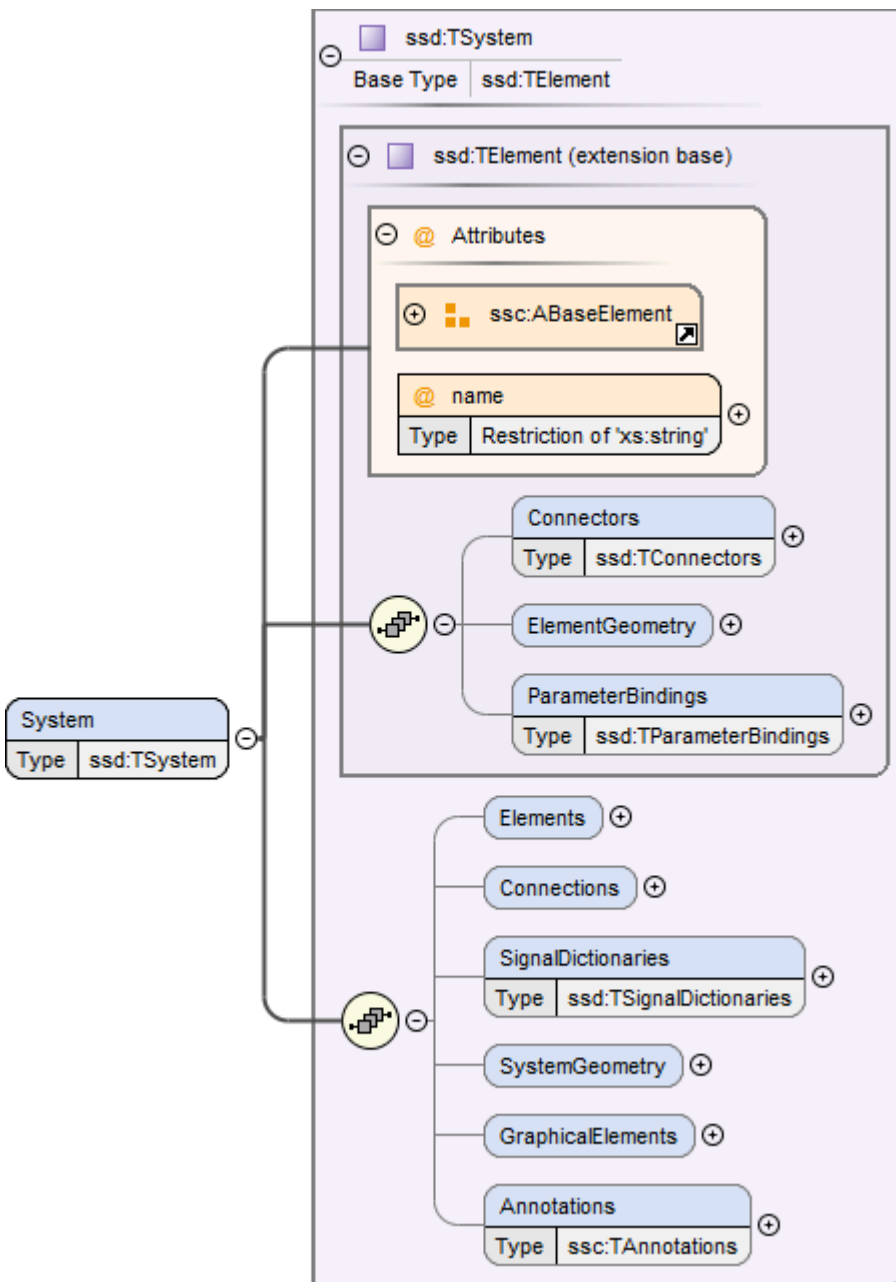
This element provides a parameter mapping, which specifies how the parameter names and values provided in the parameter source are to be mapped to the parameters of the component or system in question. If no mapping is supplied, the parameter names of the parameter source are used as is for name matching against the names of parameters in the component or system and the values of the parameter source are not transformed further before being applied.

Attribute	Description
type	Optional attribute giving the MIME type of the parameter mapping, which defaults to application/x-ssp-parameter-mapping to indicate the SSP parameter mapping file format. No further types are currently defined, but can of course be added at a later date.
source	Optional attribute indicating the source of the parameter mapping as a URI (cf. RFC 3986). For purposes of the resolution of relative URIs the base URI is the URI of the SSD, if the sourceBase attribute is not specified or is specified as SSD, and the URI of the referenced component if the base attribute is specified as component. This allows the specification of parameter mapping sources that reside inside the component (for example an FMU) through relative URIs. If the source attribute is missing, the parameter mapping MUST be provided inline as contents of the ParameterMapping element, which MUST be empty otherwise.

Attribute	Description
sourceBase	Defines the base the source URI is resolved against: If the attribute is missing or is specified as SSD, the source is resolved against the URI of the SSD, if the attribute is specified as component the URI is resolved against the (resolved) URI of the component source.

The contents of the element **MUST** be empty if the source attribute is present. If the source attribute is not present, the contents **MUST** be an ssm:ParameterMapping element, if the type attribute of this element is application/x-ssp-parameter-mapping , or any other valid XML content if the type attribute references another MIME type. In that case there **SHOULD** be a layered specification that defines how embedding the content works for that MIME type.

5.3. System

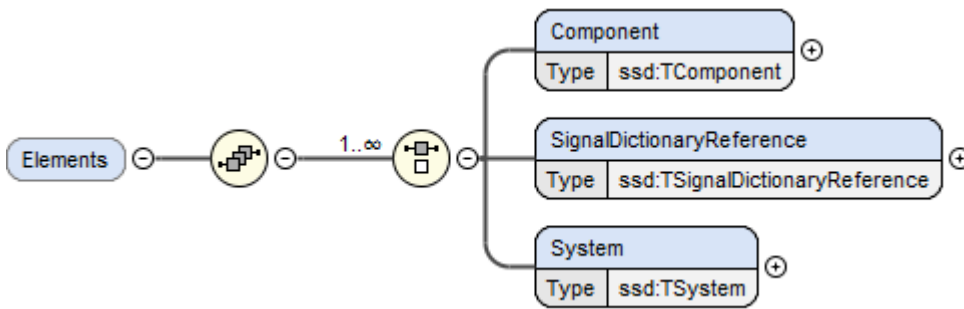


This element describes a system, which can contain components, signal dictionary references and other systems as elements, connectors as an interface to the outside world, and connections connecting the connectors of itself and of its elements to one another.

The following XML child elements are specified for the System element:

Element	Description
Elements	This optional element provides the elements contained in this system, see specification below.
Connections	This optional element provides the connections between connectors of the system, connectors of its elements and inbetween those connectors.
SignalDictionaries	This optional element provides the set of defined signal dictionaries for the system.
SystemGeometry	This optional element defines the extent of the system canvas for the system.
GraphicalElements	This optional element contains the set of purely graphical elements that are contained in the system, like notes, which have no semantic impact on the system but aid in presentation of the system in graphical user interfaces.

5.3.1. Elements

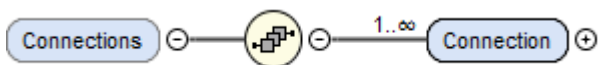


This optional element contains one or more components, signal dictionary references or systems that are the internal content of the given system.

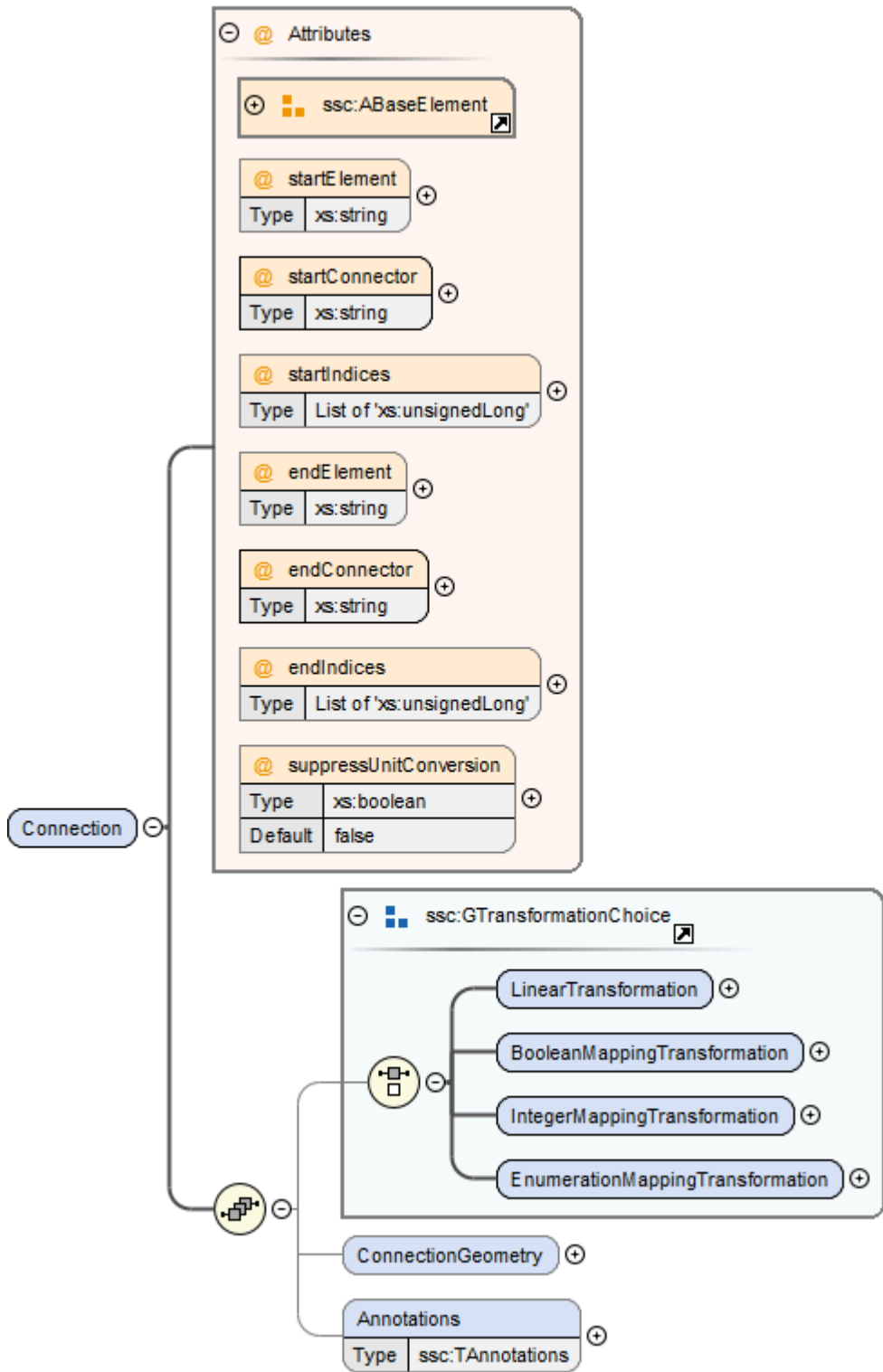
The following XML child elements are specified for the Elements element:

Element	Description
Component	A component, see Section 5.4.
SignalDictionaryReference	A reference to a signal dictionary, see Section 5.5.
System	A nested system, see Section 5.3.

5.3.2. Connections



This optional element provides the connections between connectors of the system, connectors of its elements and inbetween those connectors.



This element specifies a connection between two connectors, either of the system or its directly contained elements. Note that only connections between certain kinds of connectors are allowed, as specified in Section 5.3.2.1. Note also that the terms start and end in the attribute names of the connector, like startElement or endConnector, do not denote directionality of the data flow implied by the connector. That is determined by the combination of the semantics of the actual connectors (variables/ports) connected and their kind attributes.

Attribute	Description
startElement	Optional attribute giving the the name of the element that contains the connector given as startConnector. If the attribute is not present, then the startConnector names a connector on this system.

Attribute	Description
startConnector	Required attribute giving the name of the connector that is the start of the connection. If startElement is not supplied this indicates a connector on this system, otherwise the connector is to be found on the given element.
startIndices	Optional attribute giving the list of indices of an array connector that this connection is restricted to. If not supplied this indicates that this connection applies to the whole connector, not just a single element.
endElement	Optional attribute giving the name of the element that contains the connector given as endConnector. If the attribute is not present, then the endConnector names a connector on this system.
endConnector	Required attribute giving the name of the connector that is the end of the connection. If endElement is not supplied this indicates a connector on this system, otherwise the connector is to be found on the given element.
endIndices	Optional attribute giving the list of indices of an array connector that this connection is restricted to. If not supplied this indicates that this connection applies to the whole connector, not just a single element.
suppressUnitConversion	<p>Optional attribute specifying whether automatic conversions between start and end connector are performed using unit information potentially available for both start and end definitions.</p> <p>If this attribute is supplied and its value is true, then the environment will not perform any automatic unit conversions, otherwise automatic unit conversions can be performed.</p> <p>This is also relevant in conjunction with the optional linear transformation supplied via the LinearTransformation element: With suppressUnitConversion = true, the linear transformation is performed instead of any unit conversions, whereas otherwise the linear transformation is performed in addition to any unit conversions.</p>

5.3.2.1. Allowed Connections

The following table specifies all allowed connections, depending on the owner of the connectors (connector of element or connector of the enclosing system) and the kind of the connectors being connected. Note that source and destination in the following table indicate the resulting data flow and are unrelated to the start and end designation of a connection, as described above.

Implementations **MUST NOT** specify connections that are not of one of the allowed combinations in the following table. Implementations **MUST** ensure that data flow is specified unambiguously, including ensuring that not multiple connections with inbound data flow enter into a connector signifying an input, inout, parameter, or structuralParameter connector of an element, or a local, constant, calculatedParameter, or output connector of an enclosing system.

For connectors of kind unspecified it is ultimately implementation-defined whether and how connections are allowed, as the exact semantics depend on the underlying modeling language. For the purposes of the following table, connectors of kind unspecified are treated as connectors of whatever kind is needed to make the connection allowed, i.e. they serve a wild-card role. The handling of conflicts that arise in transitive connections from conflicting wild-card assignments is implementation-defined.

It is implementation-defined whether connections between connectors of different types are allowed, and to what extent conversions are performed. This includes type conversions that can be performed without data loss, e.g. converting from an output of type `Float32` to an input of type `Float64` or `Real`, as well as conversions that can potentially lead to data loss, e.g. converting from an output of type `Float64` to an input of type `Float32` or `Int8`. It is also implementation-defined how and whether any error-handling at runtime is performed in those cases.

It is also implementation-defined whether and which connections between connectors that are associated to different clocks are allowed.

The table below applies directly to connectors of type `Clock` with an `intervalVariability` of `triggered`. For connectors of type `Clock` with an `intervalVariability` that is not `triggered` the table applies with the following provisions: * The connector is treated as a connector of kind `output` for the purposes of determining permissible connections. * It is implementation-defined whether and which connections between two connectors of kind `input` with `intervalVariability` that is not `triggered` are allowed. Such connections are deemed to establish equality constraints on the clock ticks, where the resolution mechanism, including direction of resolution is implementation-defined.

For all connections of an element connector of type `Clock` to a system connector of type `Clock`, the `intervalVariability` of the two connectors must be identical.

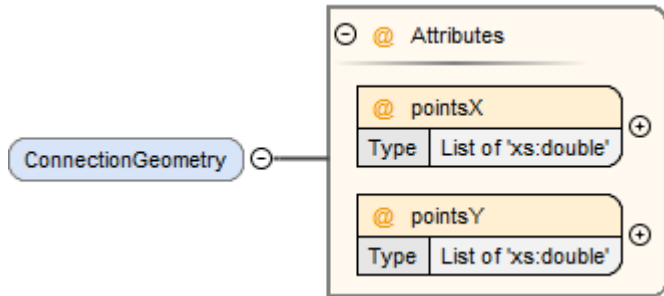
Source		Destination	
Owner	Kind	Owner	Kind
System	structuralParameter	System	calculatedParameter
System	structuralParameter	System	output
System	structuralParameter	System	local
System	parameter	System	calculatedParameter
System	parameter	System	output
System	parameter	System	local
System	input	System	output
System	input	System	local
System	structuralParameter	Element	structuralParameter
System	structuralParameter	Element	parameter
System	structuralParameter	Element	input
System	structuralParameter	Element	inout
System	parameter	Element	parameter
System	parameter	Element	input
System	parameter	Element	inout
System	input	Element	input

Source		Destination	
System	input	Element	inout
Element	constant	Element	structuralParameter
Element	constant	Element	parameter
Element	constant	Element	input
Element	constant	Element	inout
Element	calculatedParameter	Element	parameter
Element	calculatedParameter	Element	input
Element	calculatedParameter	Element	inout
Element	output	Element	input
Element	output	Element	inout
Element	local	Element	input
Element	local	Element	inout
Element	inout	Element	input
Element	constant	System	constant
Element	constant	System	calculatedParameter
Element	constant	System	output
Element	constant	System	local
Element	calculatedParameter	System	calculatedParameter
Element	calculatedParameter	System	output
Element	calculatedParameter	System	local
Element	output	System	output
Element	output	System	local
Element	local	System	output
Element	local	System	local
Element	inout	System	output
Element	inout	System	local

The following XML child elements are specified for the Connection element:

Element	Description
LinearTransformation / BooleanMappingTransformation / IntegerMappingTransformation / EnumerationMappingTransformation	Specifies an optional transformation for the connection. If any, exactly one of these elements MUST be present to specify the type of the transformation. See Section 4.5.2 for details.
ConnectionGeometry	This optional element defines the geometry information of the connection.

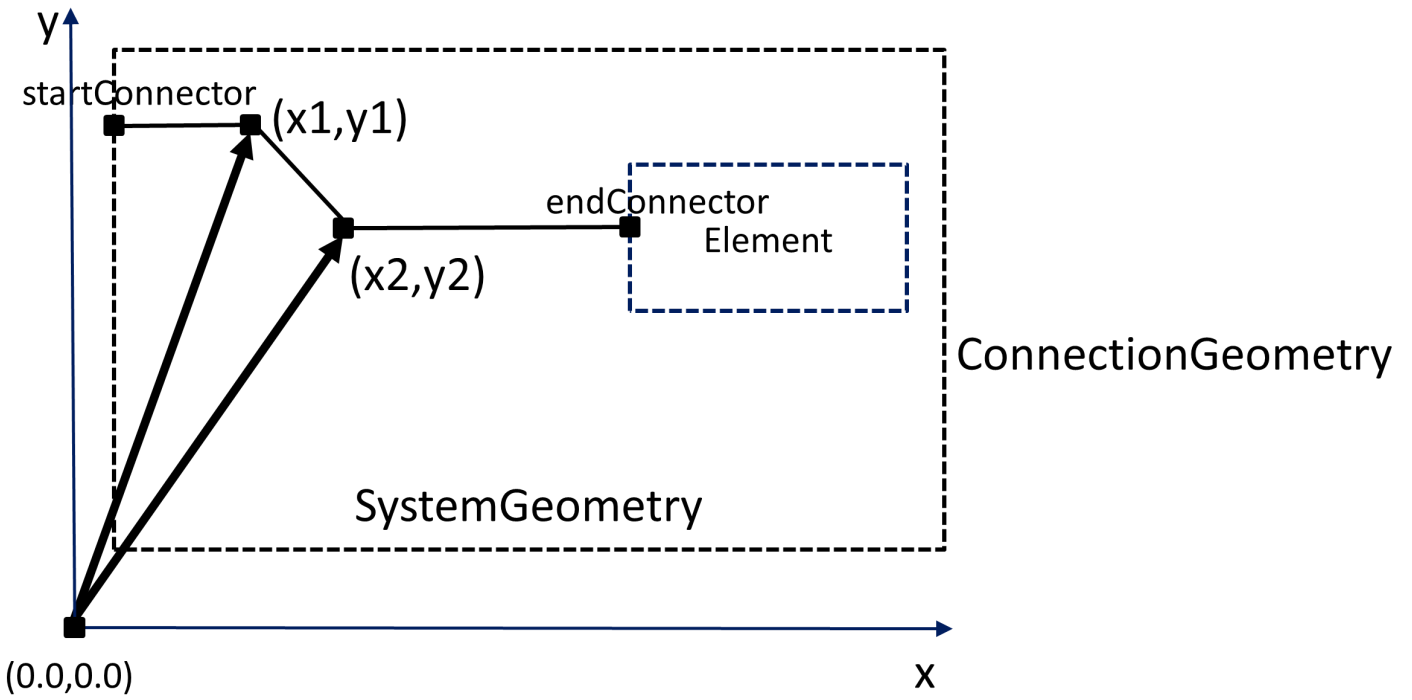
5.3.2.2. ConnectionGeometry



This optional element defines the geometry information of the connection. The start and end coordinates of the connection are derived automatically through the coordinates of the corresponding connectors. The only relevant geometry information provided by the connection geometry is a, by default empty, list of intermediate waypoint coordinates, which are to be interpreted as for the `svg:polyline` primitive, i.e. as waypoints for straight line segments, with the first and last points added automatically based on the translated coordinates of the start and end connectors. Note that x and y coordinates are in the coordinate system of the enclosing system.

Attribute	Description
pointsX	Required attribute giving a list of x coordinates of the intermediate waypoints.
pointsY	Required attribute giving a list of y coordinates of the intermediate waypoints.

[Graphical example for a ConnectionGeometry:

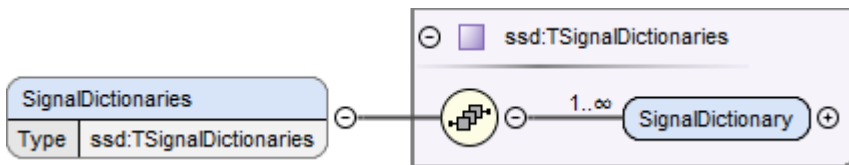


]

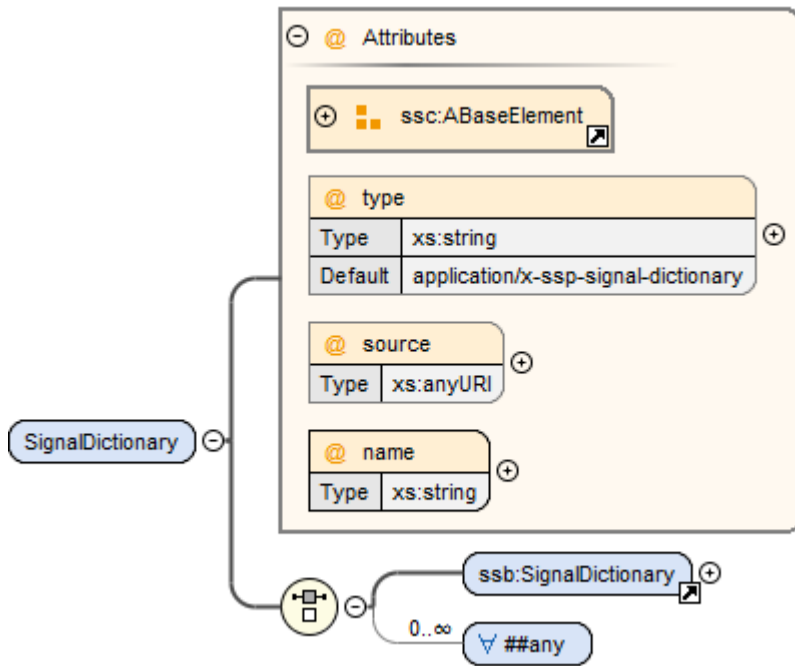
5.3.3. SignalDictionaries

Signal dictionaries can be seen as a description of a collection of signals. Such collections can also be seen as a "signal bus" (like a CAN-bus in embedded systems). One can use a signal dictionary as a specification of how a collection of signals shall look like with definition of signal names and their units during a design phase. When a large number of signals have to be handled, signal dictionaries can help to keep a system description clearly represented.

Another benefit of signal dictionaries is the possibility to define a mapping between two or more signal dictionaries that may differ by names or units, which is a common case when components are integrated into a system that come from different sources without a common design or architecture.



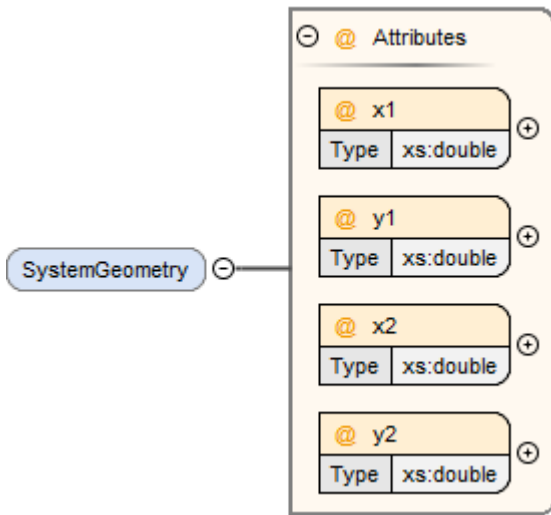
This optional element provides the set of defined signal dictionaries for the system.



A signal dictionary is a collection of signals which can be accessed in different systems at different levels of the hierarchy through signal dictionary references referencing the signal dictionary.

Attribute	Description
name	Required attribute giving the signal dictionary a name, which shall be unique within the directly enclosing system. The name is used for purposes of specifying the signal dictionary referenced by a signal dictionary reference. Name lookups occur in hierarchical fashion, i.e. the name is first looked up in the system that contains a signal dictionary reference. If that lookup yields no match, the lookup is performed on the enclosing system, etc., until a match is found. It is an error if no matching signal dictionary is found.
type	Optional attribute giving the MIME type of the signal dictionary, which defaults to <code>application/x-ssp-signal-dictionary</code> to indicate the SSP signal dictionary file format. No further types are currently defined, but can of course be added at a later date.
source	This attribute indicates the source of the signal dictionary as a URI (cf. RFC 3986). For purposes of the resolution of relative URIs the base URI is the URI of the SSD. If the source attribute is missing, the signal dictionary MUST be provided inline as contents of the <code>SignalDictionary</code> element, which MUST be empty otherwise. For the default type <code>application/x-ssp-signal-dictionary</code> such inline content MUST be a <code>SignalDictionary</code> from the <code>SystemStructureSignalDictionary</code> namespace. See Chapter 8 for details.

5.3.4. SystemGeometry



This element defines the extent of the system canvas. (x1,y1) and (x2,y2) define the lower-left and upper-right corner, respectively. Different from ElementGeometry, where $x1 > x2$ and $y1 > y2$ indicate flipping, $x1 < x2$ and $y1 < y2$ **MUST** hold here.

If undefined, the system canvas extent defaults to the bounding box of all ElementGeometry elements of the child elements of the system.

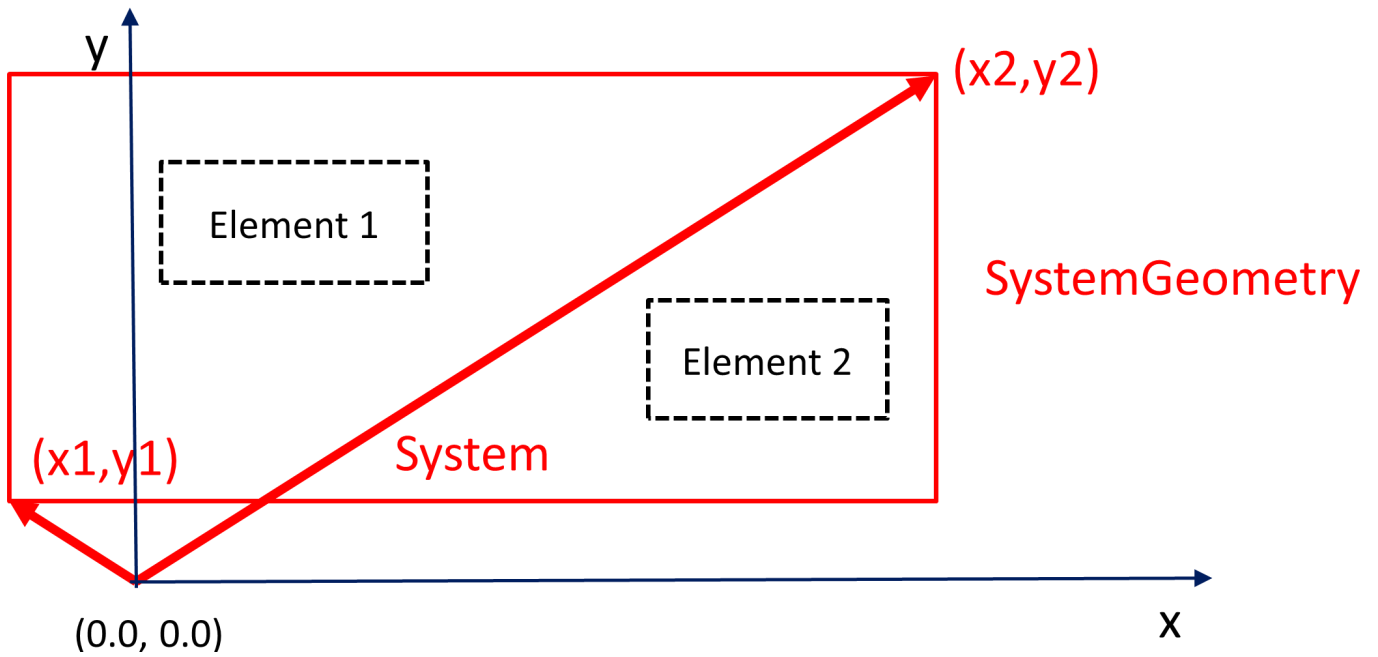
When displaying the content of a sub-system together with the enclosing parent system, the transformation of co-ordinates inside the sub-system to co-ordinates in the parent system is defined by the transformation from $\text{SystemGeometry}\{x1,y1,x2,y2\}$ to $\text{ElementGeometry}\{x1',y1',x2',y2'\}$, where $\text{ElementGeometry.z}'$ is the respective coordinate of the sub-system when instantiated in the parent system after rotation.

When importing or exporting systems, the nominal unit of the coordinates is 1 mm for all axis. The nominal unit is intended to ensure similar visual sizing and appearances when combining systems from different implementations.

[*The visual appearance of a length of 1 should be (roughly) 1 mm. Importing and exporting tools that support a graphical representation might use different coordinate systems. This common unit for coordinates is defined to allow a seamless integration of SSPs from different sources. Without such a common unit, an SSP exported in one tool might appear huge or tiny in the other tool. Hence, the exporting tool has to scale from its own coordinate system when exporting and the importing tool has to scale to its own coordinate system when importing an SSP.*]

Attribute	Description
x1	Required attribute giving the x coordinate of the lower-left corner of the system canvas.
y1	Required attribute giving the y coordinate of the lower-left corner of the system canvas.
x2	Required attribute giving the x coordinate of the upper-right corner of the system canvas.
y2	Required attribute giving the y coordinate of the upper-right corner of the system canvas.

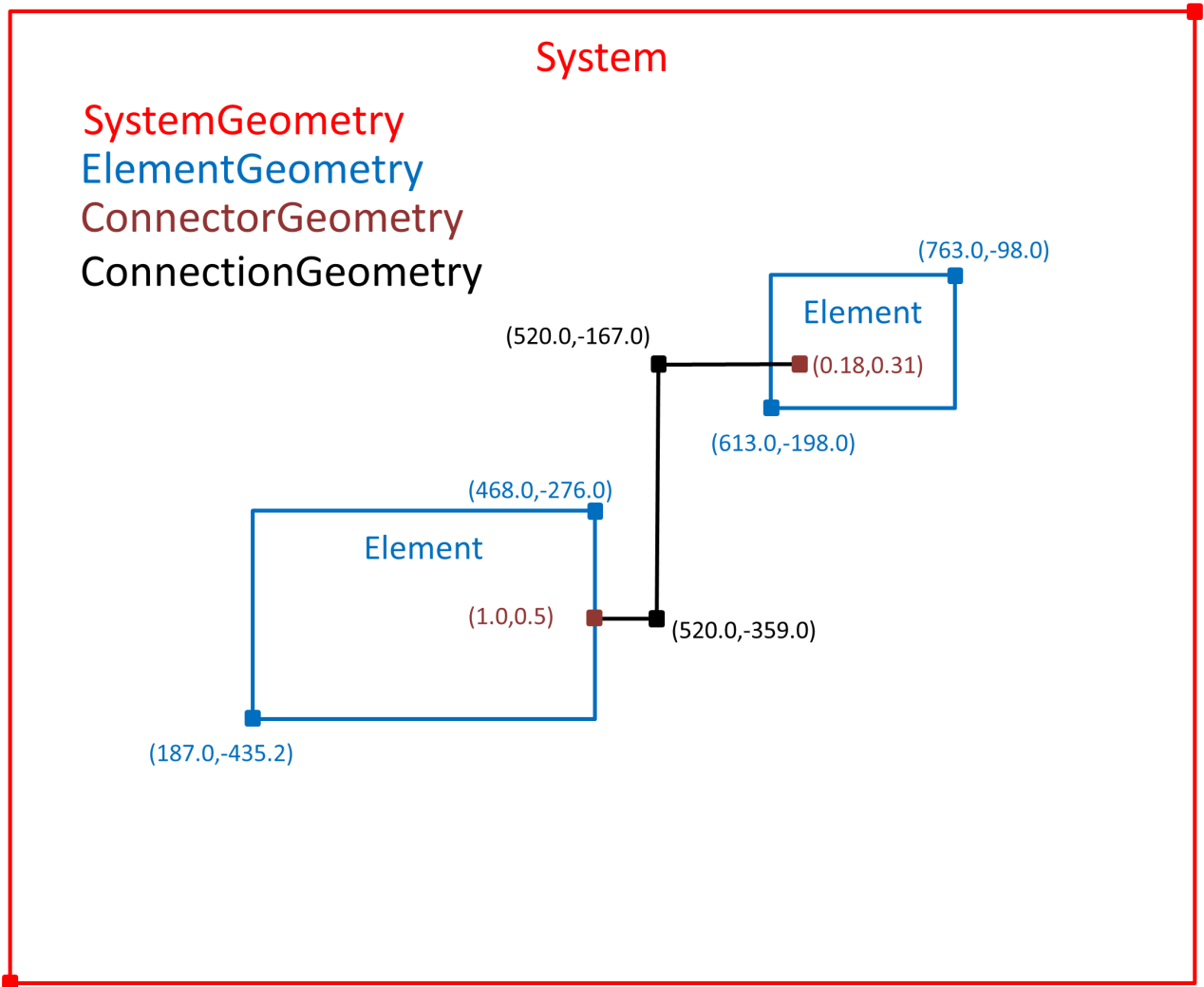
[Graphical example for a SystemGeometry:



]

[Graphical example showing the interplay of SystemGeometry, ElementGeometry, ConnectorGeometry, and ConnectionGeometry:

(963.0,102.0)

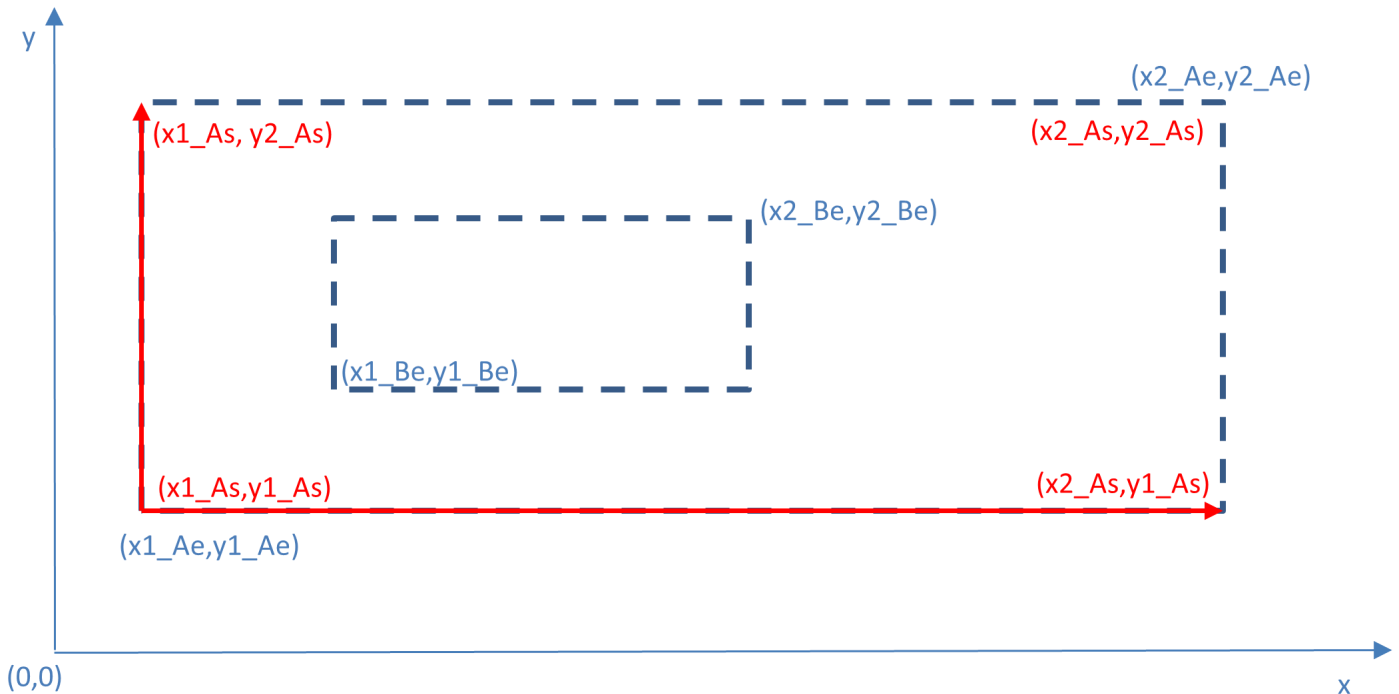


]

[Example how the given Geometries can be used to transform coordinates to show elements on different hierarchy levels in a single graphic:

Subsystem A is an element with an ElementGeometry $(x1_Ae, y1_Ae, x2_Ae, y2_Ae)$ and a SystemGeometry $(x1_As, y1_As, x2_As, y2_As)$.

B is an element in subsystem A with an ElementGeometry coordinates $(x1_Be, y1_Be, x2_Be, y2_Be)$.



To plot the element B in the system where A is located, use the following coordinate transformation:

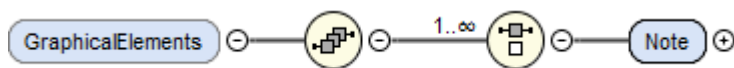
$$x1_Be \rightarrow (x1_Ae + (x1_Be - x1_As) * (x2_Ae - x1_Ae) / (x2_As - x1_As))$$

$$y1_Be \rightarrow (y1_Ae + (y1_Be - y1_As) * (y2_Ae - y1_Ae) / (y2_As - y1_As))$$

$$x2_Be \rightarrow (x1_Ae + (x2_Be - x1_As) * (x2_Ae - x1_Ae) / (x2_As - x1_As))$$

$$y2_Be \rightarrow (y1_Ae + (y2_Be - y1_As) * (y2_Ae - y1_Ae) / (y2_As - y1_As))]$$

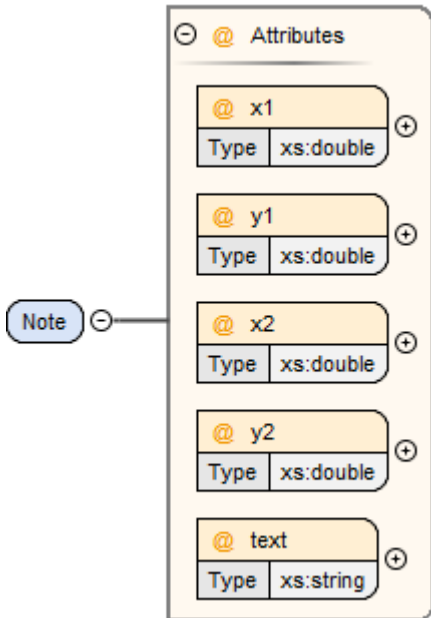
5.3.5. GraphicalElements



This optional element contains the set of purely graphical elements that are contained in the system, like notes, which have no semantic impact on the system but aid in presentation of the system in graphical user interfaces.

Currently the only graphical element defined is the Note element, which allows for simple textual notes to be placed into the system diagram, but in the future more elements might be added as needed for exchange of graphical information.

5.3.5.1. Note

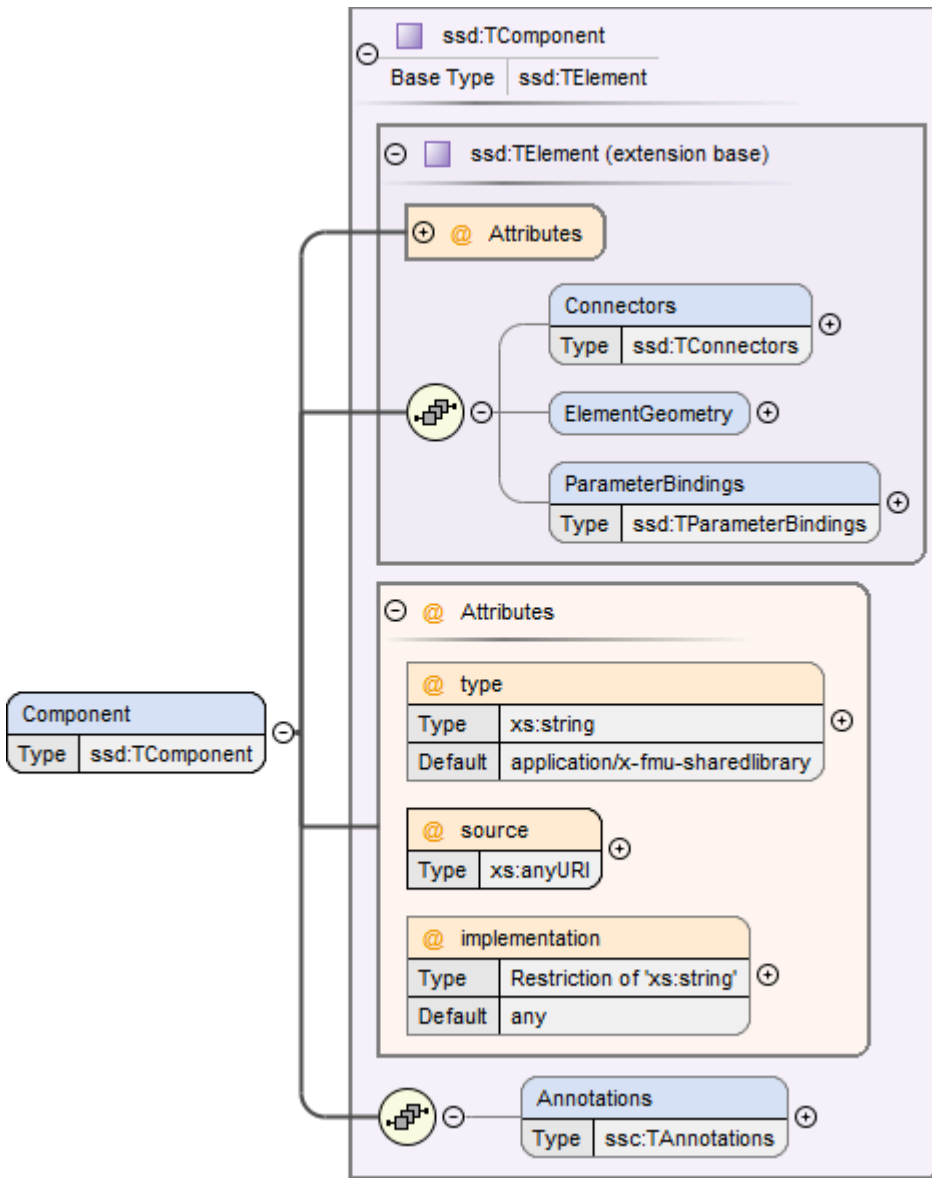


This element defines a graphical note to be placed on the canvas of the enclosing system. It is sized using the attributes so that the coordinates (x1,y1) and (x2,y2) define the positions of the lower-left and upper-right corners of the note in the coordinate system of the parent.

The note text is given by the text attribute. The presentation expectation is that the text is automatically sized and wrapped in such a way that it fits the note area. If this would lead to too small text, it might be necessary to provide an interactive method (like expanding triangle, or popup, or other means) to show the remainder of the note text. Inside the text attribute, newlines indicate paragraph breaks.

Attribute	Description
x1	Required attribute giving the x coordinate of the lower-left corner of the note.
y1	Required attribute giving the y coordinate of the lower-left corner of the note.
x2	Required attribute giving the x coordinate of the upper-right corner of the note.
y2	Required attribute giving the y coordinate of the upper-right corner of the note.

5.4. Component

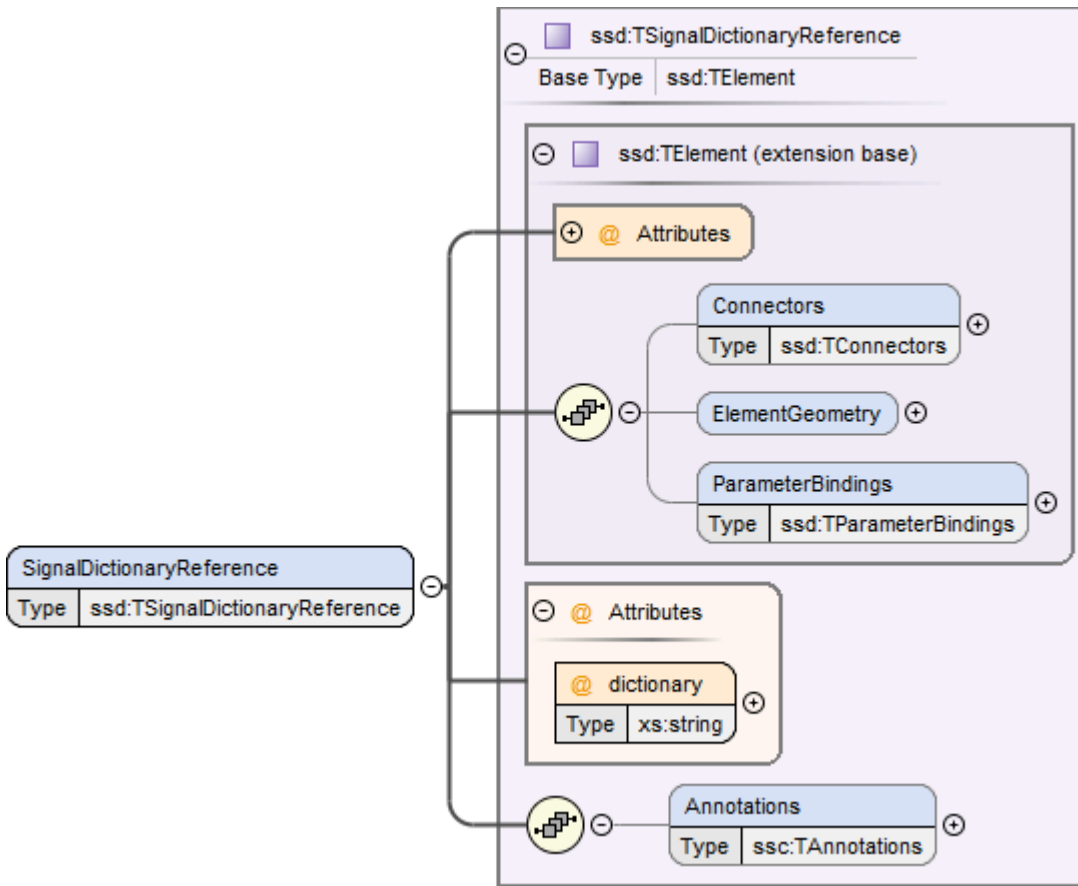


A component is an atomic element of a system (i.e. its internal structure is not specified).

Attribute	Description
type	Optional attribute giving the MIME type of the component, which defaults to <code>application/x-fmu-sharedlibrary</code> to indicate the type of the component. Valid further types are <code>application/x-ssp-definition</code> for system structure description files, <code>application/x-ssp-package</code> for system structure package files, and <code>text/x-modelica</code> for Modelica models. No further types are currently defined. For type <code>text/x-modelica</code> , a media type parameter <code>path</code> specifies the full path of the Modelica class. [<i>Example:</i> <code>type="text/x-modelica; path=Modelica.Mechanics.Rotational.Interface.Flange_A" .]</code>

Attribute	Description
source	<p>Optional attribute indicating the source of the component as a URI (cf. RFC 3986). For purposes of the resolution of relative URIs the base URI is the URI of the SSD. Therefore for components that are located alongside the SSD, relative URIs without scheme and authority CAN and SHOULD be used to specify the component sources. For components that are packaged inside an SSP that contains this SSD, this is REQUIRED (in this way, the SSD URIs remain valid after unpacking the SSP into the filesystem).</p> <p>[For example for an FMU called <i>MyDemoFMU.fmu</i>, that is located in the resources directory of an SSP, the correct URI would be <i>resources/MyDemoFMU.fmu</i>.]</p> <p>When referencing another SSP, by default the default SSD of the SSP (i.e. <code>SystemStructure.ssd</code>) is referenced. When a non-default SSD should be selected, then the name of the non-default SSD MUST be given through a fragment identifier, i.e. the URI <code>resources/SubSSP.ssp#VariantB.ssd</code> would reference the <code>VariantB.ssd</code> of <code>SubSSP.ssp</code> located in the resources directory relative to this SSD.</p> <p>When the URI is a same-document URI with a fragment identifier, for example <code>#other-system</code>, then the fragment identifier MUST identify a system element in this SSD document with an id attribute identical to the fragment identifier. This mechanism can be used to instantiate an embedded system definition multiple times through reference to its definition element.</p> <p>Note that implementations are only REQUIRED to support relative URIs as specified above, and that especially relative URIs that move beyond the baseURI (i.e. go up a level via <code>..</code>) are not required to be supported by implementations, and are in fact often not supported for security or other reasons. Implementations are also not required to support any absolute URIs and any specific URI schemes, but are of course allowed to support any and all kinds of URIs where this is considered useful.</p> <p>If the source attribute is missing, this indicates that there is no provided source for the component, indicating a simulation architecture design without complete executable implementation. Implementations CAN take any specified type attribute into account when handling such components. In any other regard implementations CAN treat such components as equivalent to an empty system with the same connectors and other properties as specified for the component.</p> <p>Note that not specifying a source attribute is not the same as specifying a source attribute with an empty string value, as that is considered a valid relative URI. Implementations MUST NOT specify an empty relative URI to indicate a missing implementation.</p>
implementation	<p>When the referenced component is an FMU that contains multiple implementations [for example <i>Co-Simulation and Model Exchange</i>], this optional attribute can be used to determine which FMU implementation should be employed. If the attribute is missing or uses the default value any, the importing tool is free to choose what kind of FMU implementation to use. If the value is <code>CoSimulation</code>, <code>ModelExchange</code>, or <code>ScheduledExecution</code> the corresponding FMU implementation MUST be used. It is an error if the specified type of FMU implementation is not present in the FMU.</p>

5.5. SignalDictionaryReference



A signal dictionary reference is an element of a system that references a signal dictionary, i.e. it is the place-holder of the signal dictionary that allows access to the contents of the signal dictionary through its connectors, which **MUST** reference signal dictionary entries.

Attribute	Description
dictionary	<p>This required attribute gives the name of the signal dictionary that is to be referenced. Name lookups occur in hierarchical fashion, i.e. the name is first looked up in the system that contains a signal dictionary reference. If that lookup yields no match, the lookup is performed on the enclosing system, etc., until a match is found.</p> <p>It is an error if no matching signal dictionary is found.</p>

6. System Structure Parameter Values (SSV)

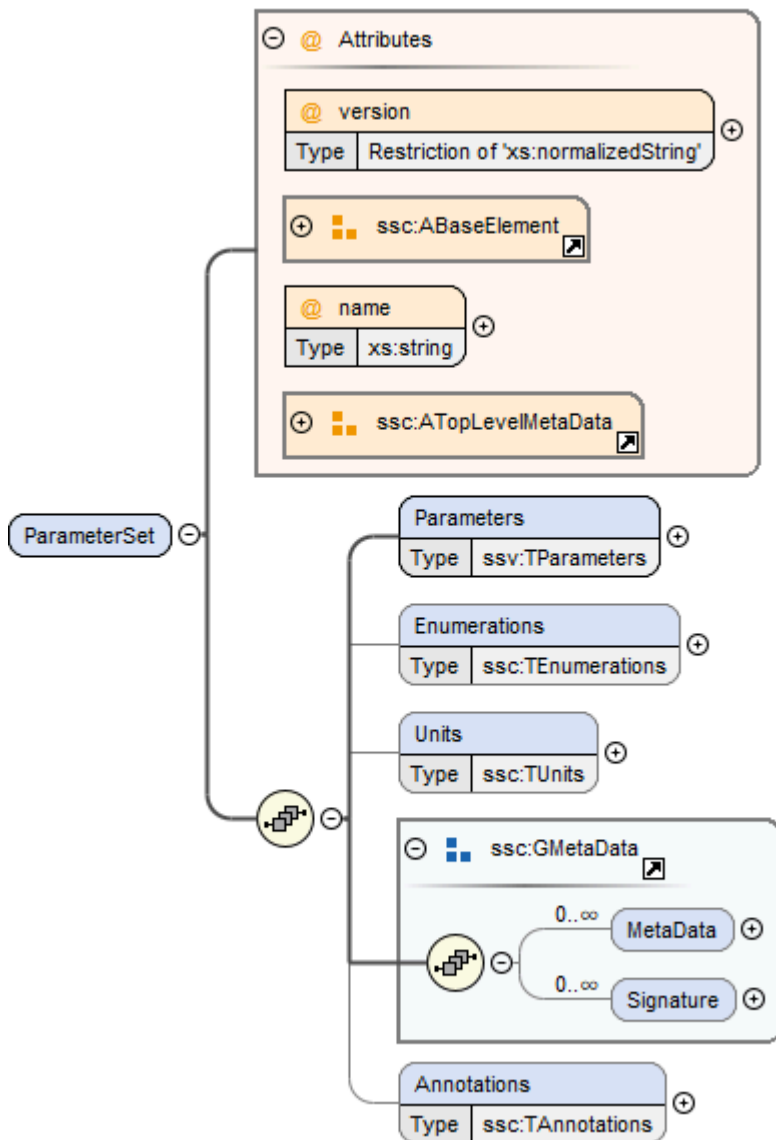
A System Structure Parameter Values (abbreviated SSV) element provides parameter sets for a component or system. The XML element can be inlined with its parent element or referenced from the parent element and supplied as a separate file that is either included within an SSP package or specified as an external URL.

For information on hierarchical naming structure and precedence rules, see Section 5.2.3.

An SSV file **MUST** be a well-formed XML 1.0 [XML10] file that conforms to the SystemStructureParameterValues XML Schema that is distributed as part of this standard. The file **MUST** use the UTF-8 encoding. All SSV-specific elements live in the `http://ssp-standard.org/SSP1/SystemStructureParameterValues` namespace, nicknamed `ssv`.

It is **RECOMMENDED** that the file extension `.ssv` be used for stand-alone SSV files. Except for this file extension recommendation the filename is arbitrary and is independent of variant handling or the names of SSD files.

6.1. ParameterSet



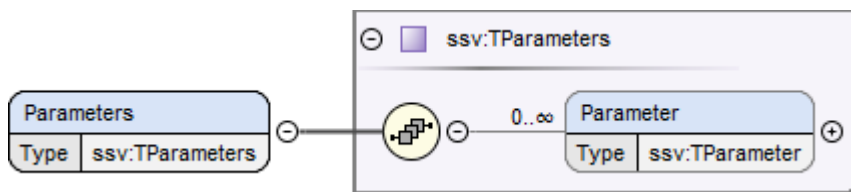
The `ParameterSet` element contains parameter and meta data information. If the SSV is provided as a separate file, the root element **MUST** be a `ParameterSet` element.

Attribute	Description
version	This required attribute specifies the version of this specification that the parameter set conforms to. Only major and minor version number are included, the patch version number MUST NOT be included in this attribute. For the current release this MUST be 1.0.
name	This required attribute provides a name which can be used for purposes of presenting the parameter set to the user.

The following child elements are specified for the ParameterSet element:

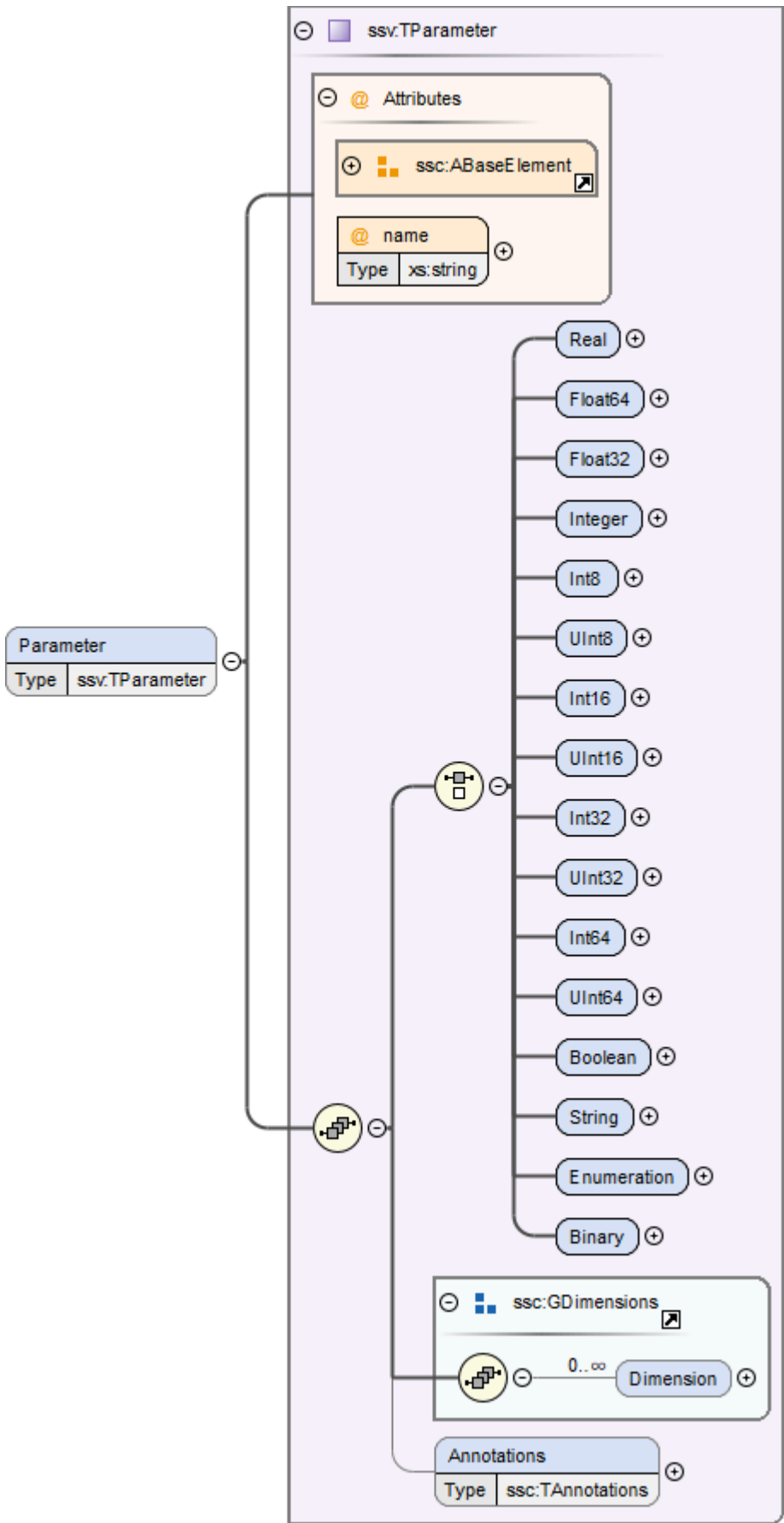
Element	Description
Parameters	This required element specifies the parameters in the parameter set. See below for details.
Enumerations	This optional element MUST contain definitions for all enumerations referenced in the parameter set. See Section 4.4.1 for its definition.
Units	This optional element MUST contain definitions for all units referenced in the parameter set. See Section 4.4.2 for its definition.

6.2. Parameters



The Parameters element contains a list of individual parameters. If the list is empty, the parameter set **SHALL** not have any effect on any system or component it is applied to.

It is **not required** that all parameters included in the Parameters element correspond to parameters available in the components or systems the parameter set is applied to (through ParameterBinding elements in the system structure description). This allows the definition of large parameter data sets out of which only a subset is applied in a given case. See Section 5.2.3 for the semantic definition of parameter bindings.



The following XML attributes are specified for the Parameter element:

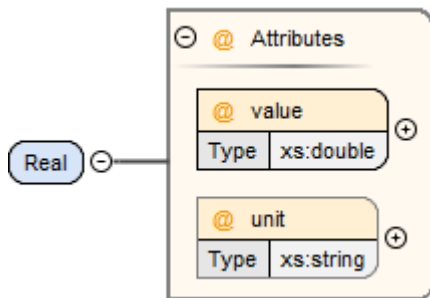
Attribute	Description
name	This required attribute specifies the name of the parameter in the parameter set. The name MUST be unique within the parameter set.

The following XML child elements are specified for the Parameter element:

Element	Description
Real / Float64 / Float32 / Integer / Int8 / UInt8 / Int16 / UInt16 / Int32 / UInt32 / Int64 / UInt64 / Boolean / String / Enumeration / Binary	Exactly one of these elements MUST be present to specify the type of the parameter. See below for details on each type.
Dimension	One or more of these optional elements specify the parameter array dimensions, making the parameter an array parameter. See Section 4.5.3 for details.

The dimensionality of the parameter is given by the presence of one or more Dimension elements.

6.2.1. Real

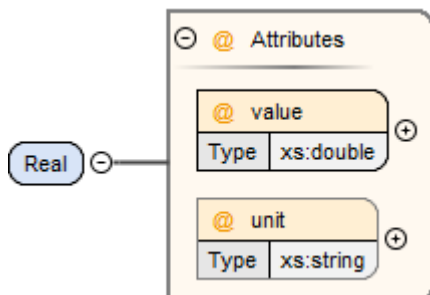


This type specifies a parameter that represents an IEEE754 double precision floating point number, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.
unit	This optional attribute gives the name of the unit of the parameter. The name MUST match the name of a unit defined in the Units element in the ParameterSet root element.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.2. Float64

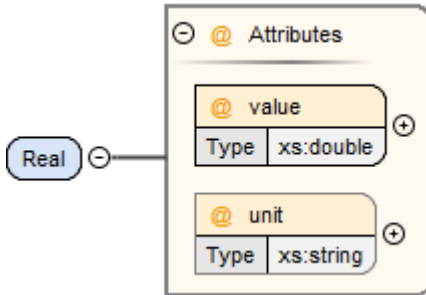


This type specifies a parameter that represents an IEEE754 double precision floating point number, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.
unit	This optional attribute gives the name of the unit of the parameter. The name MUST match the name of a unit defined in the Units element in the ParameterSet root element.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.3. Float32

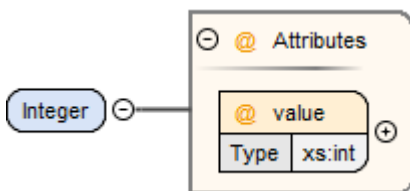


This type specifies a parameter that represents an IEEE754 single precision floating point number, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.
unit	This optional attribute gives the name of the unit of the parameter. The name MUST match the name of a unit defined in the Units element in the ParameterSet root element.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.4. Integer

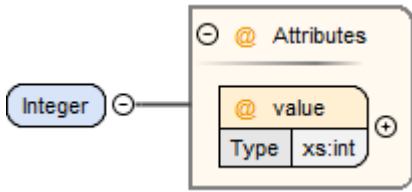


This type specifies a parameter that represents a 32-bit signed integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.5. Int8

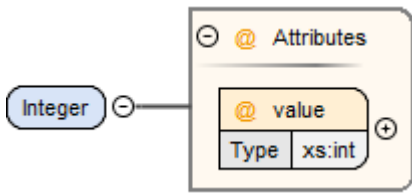


This type specifies a parameter that represents a 8-bit signed integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.6. UInt8

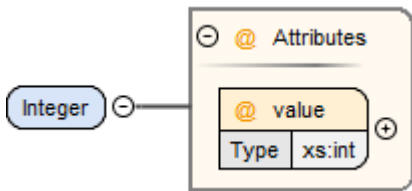


This type specifies a parameter that represents a 8-bit unsigned integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.7. Int16

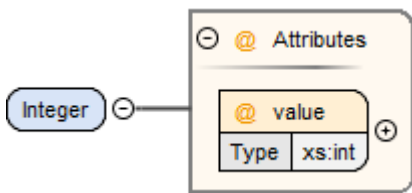


This type specifies a parameter that represents a 16-bit signed integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.8. UInt16

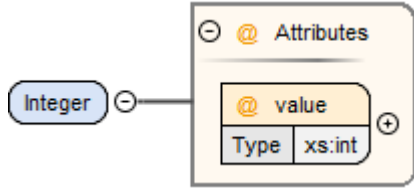


This type specifies a parameter that represents a 16-bit unsigned integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.9. Int32

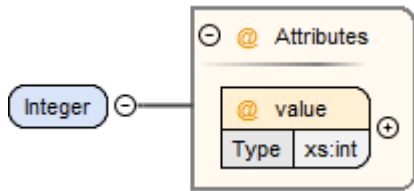


This type specifies a parameter that represents a 32-bit signed integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.10. UInt32

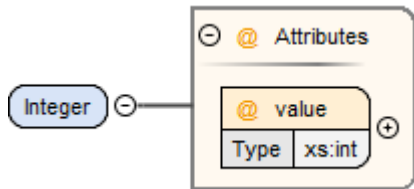


This type specifies a parameter that represents a 32-bit unsigned integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.11. Int64

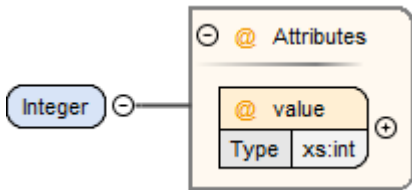


This type specifies a parameter that represents a 64-bit signed integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.12. UInt64

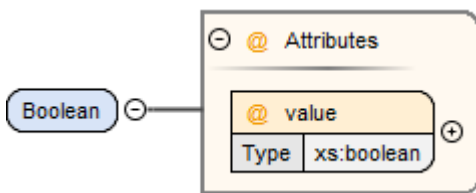


This type specifies a parameter that represents a 64-bit unsigned integer, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.13. Boolean

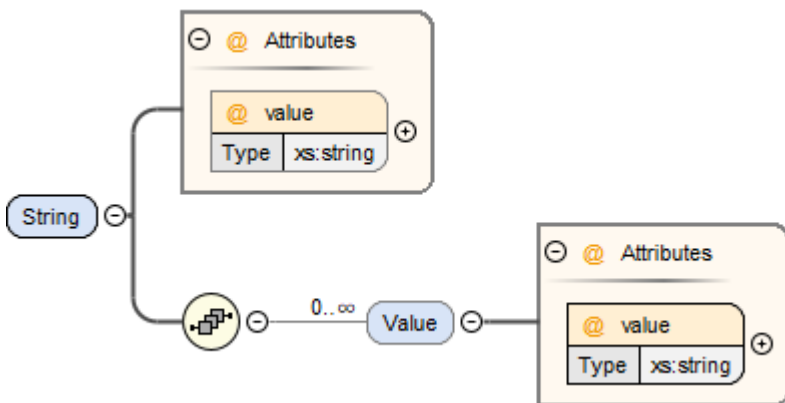


This type specifies a parameter that represents a Boolean value, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

For array parameters, values are specified as a space-separated list of values in row-major order, as specified in FMI.

6.2.14. String



This type specifies a parameter that represents a zero-terminated UTF-8 encoded string, or an array of such values.

Attribute	Description
value	This required attribute specifies the value of the parameter.

The value of the parameter can alternatively be specified using one or more Value child elements:

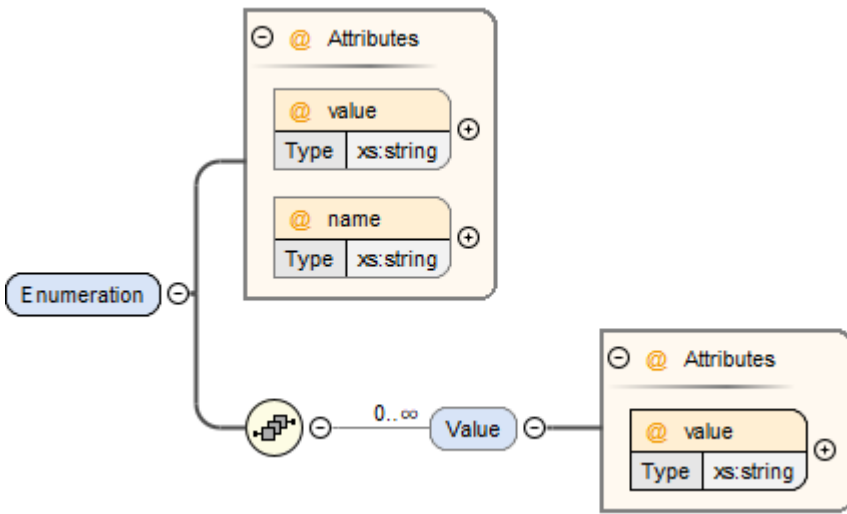
Element	Description
Value	One or more of these optional elements provide individual parameter values, as an alternative to the singular value attribute on the String element.

It is an error if both value attribute and Value child elements are present.

For scalar parameters, or array parameters with a single element, either way of specifying the singular value can be used.

For array parameters with more than one element, values **MUST** be specified as child elements, with each element providing one element value in row-major order, as specified in FMI.

6.2.15. Enumeration



This type specifies a parameter that represents an enumeration value, or an array of such values, as specified by an enumeration definition.

Attribute	Description
value	This required attribute specifies the value of the parameter as the enumeration item name. Note that the actual numeric value this value is mapped to at run time will depend on the item mapping of the enumeration type of the variables being parameterized.
name	<p>This optional attribute specifies the name of the enumeration type that the parameter references. If it is supplied, the name MUST match the name of an enumeration type defined in the Enumerations element in the ParameterSet root element.</p> <p>This attribute is optional; if it is not specified, then the list of valid enumeration items with their names and values is not specified, and the interpretation of the enumeration value is left solely to the variables that are being parameterized.</p> <p>If the attribute is specified, implementations MAY use that information for user interface purposes, and/or for additional consistency checking.</p> <p>[Note: the level of consistency checking is left optional by design, since mandating consistency checking across files requires unified types across files coming potentially from different sources, which is not always realistically possible.]</p>

The value of the parameter can alternatively be specified using one or more Value child elements:

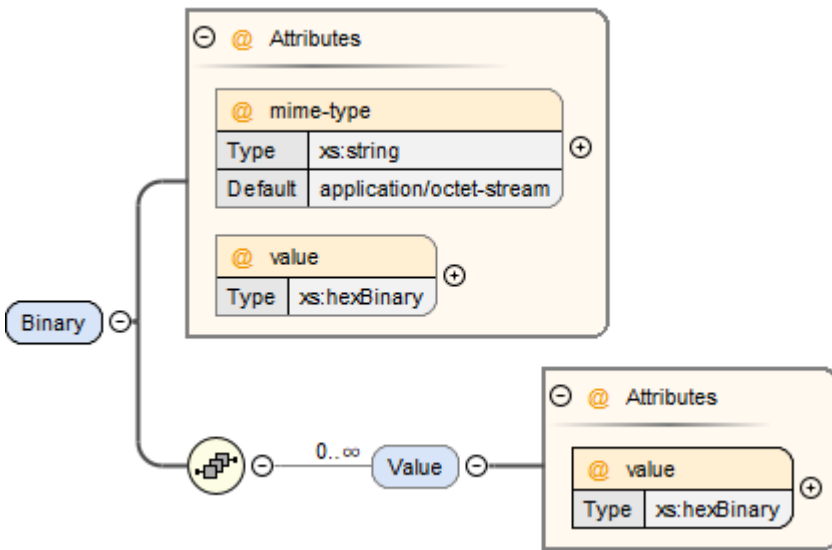
Element	Description
Value	One or more of these optional elements provide individual parameter values, as an alternative to the singular value attribute on the Enumeration element.

It is an error if both value attribute and Value child elements are present.

For scalar parameters, or array parameters with a single element, either way of specifying the singular value can be used.

For array parameters with more than one element, values **MUST** be specified as child elements, with each element providing one element value in row-major order, as specified in FMI.

6.2.16. Binary



This type specifies a parameter that represents a length-terminated binary data type, or an array of such values.

Attribute	Description
value	This attribute gives the value of the parameter as a hex-encoded binary value.
mime-type	This optional attribute specifies the MIME type of the underlying binary data, which defaults to the non-specific <code>application/octet-stream</code> type. This information can be used by the implementation to detect mismatches between binary parameters, or to provide automatic conversions between different formats. It should be noted that the implementation is not required to provide this service, i.e. it remains the responsibility of the operator to ensure only compatible binary connectors/parameters are connected.

The value of the parameter can alternatively be specified using one or more Value child elements:

Element	Description
Value	One or more of these optional elements provide individual parameter values, as an alternative to the singular value attribute on the Binary element.

It is an error if both value attribute and Value child elements are present.

For scalar parameters, or array parameters with a single element, either way of specifying the singular value can be used.

For array parameters with more than one element, values **MUST** be specified as child elements, with each element providing one element value in row-major order, as specified in FMI.

7. System Structure Parameter Mapping (SSM)

A parameter mapping describes a mapping between the parameters in a parameter source and the actual parameters of a system or component to which the parameters are to be applied. The mapping maps the names of parameters in the source to the names of the parameters in the system or component that are to be parametrized. It can also optionally provide for transformations that are to be applied on the value of the parameters prior to them being applied.

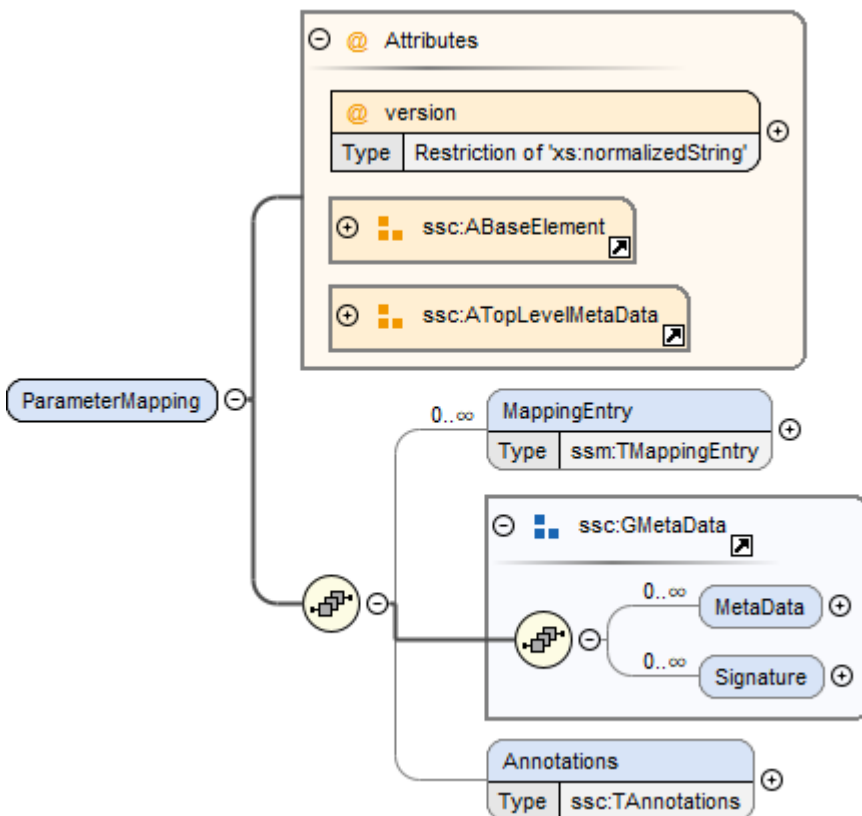
A parameter mapping can be provided either as a stand-alone XML file (an SSM file), which can be referenced from SSD files, or it can be embedded in an `ssd:ParameterMapping` element of the SSD directly (see Section 5.2.3.2).

An SSM file **MUST** be a well-formed XML 1.0 [XML10] file that conforms to the SystemStructureParameterMapping XML Schema that is distributed as part of this standard. The file **MUST** use the UTF-8 encoding. All SSM-specific elements live in the `http://ssp-standard.org/SSP1/SystemStructureParameterMapping` namespace, nicknamed `ssm`.

It is **RECOMMENDED** that the file extension `.ssm` be used for stand-alone SSM files. Except for this file extension recommendation the filename is arbitrary and is independent of variant handling or the names of SSD files.

The root element of an SSM file **MUST** be a `ParameterMapping` element, which contains an arbitrary number of `MappingEntry` elements.

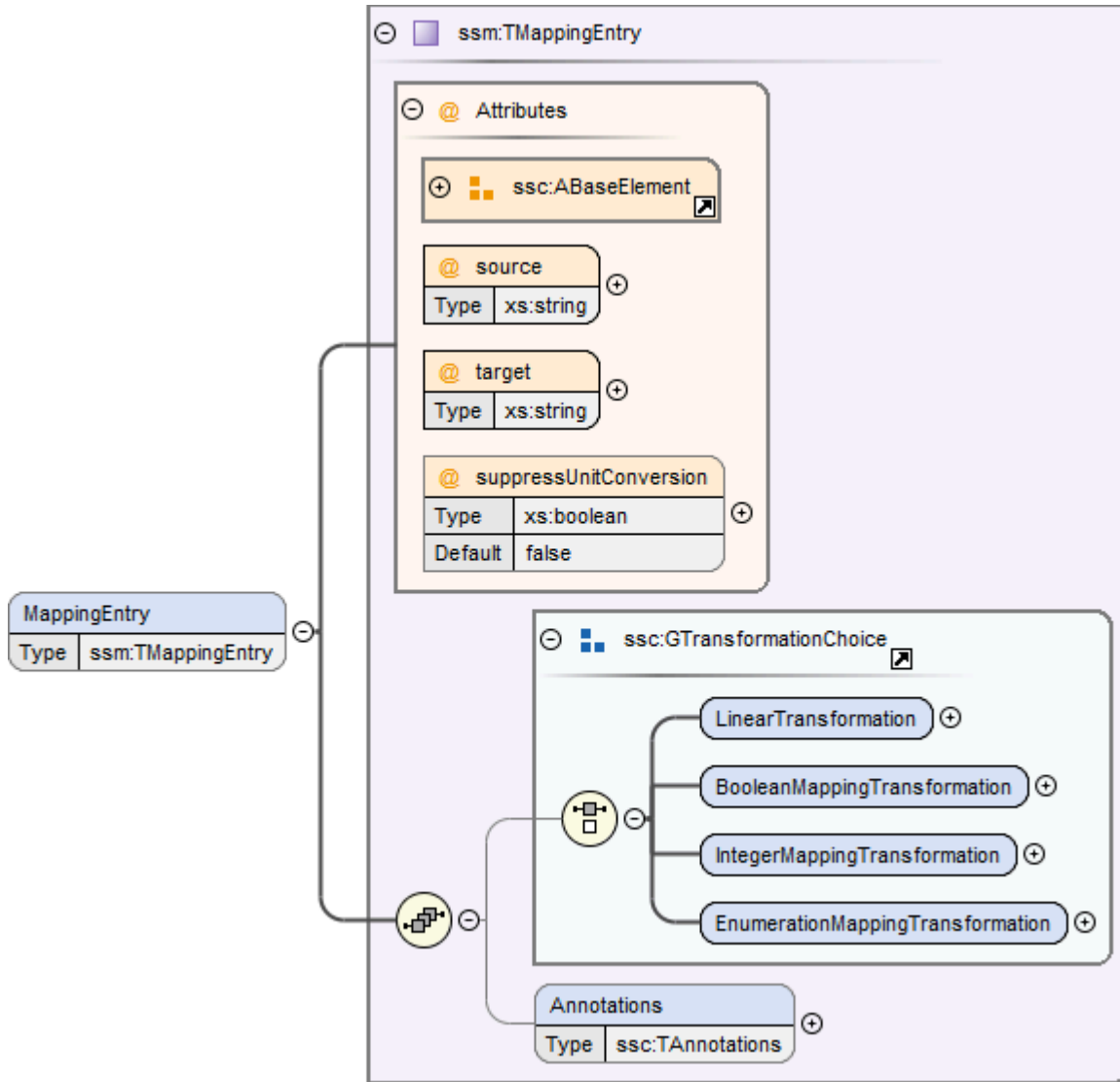
7.1. ParameterMapping



This element describes a parameter mapping, which consists of multiple mapping entries, each describing one parameter mapping (see next section). The parameter mapping **MUST** contain entries for all parameters that are going to be mapped. All parameters of the parameter source which are not referenced in a mapping entry will not be applied. All parameters that are referenced in a mapping entry will only be applied using the name they are mapped to, i.e. any original name is disregarded for applying parameters. Implementations **MUST NOT** map multiple parameters to the same name. Implementations **CAN** map the same parameter to multiple names.

Attribute	Description
version	This required attribute specifies the version of this specification that the parameter mapping conforms to. Only major and minor version number are included, the patch version number MUST NOT be included in this attribute. For the current release this MUST be 1.0.

7.1.1. MappingEntry



This element specifies a single mapping between a parameter in the source and a parameter of the system or component being parametrized. Through its optional GTransformationChoice element a transformation can be specified that is to be applied to the parameter value prior to its application to its target parameter.

Attribute	Description
source	This required attribute specifies the name of the parameter in the parameter source that is to be mapped to a new name and/or provided with a transformation in this mapping entry.
target	This required attribute specifies the name of the parameter in the system or component that is to be parametrized, i.e. that is the target of this mapping entry.

Attribute	Description
suppressUnitConversion	<p>This optional attribute specifies whether automatic conversions between parameter source and its target are performed using unit information potentially available for both value and target definitions. If this attribute is supplied and its value is true, then the environment will not perform any automatic unit conversions, otherwise automatic unit conversions can be performed.</p> <p>This is also important in conjunction with the optional linear transformation supplied via the LinearTransformation element: With suppressUnitConversion = true, the linear transformation is performed instead of any unit conversions, whereas otherwise the linear transformation is performed in addition to any unit conversions. In that case the specified transformation will be done after any unit conversions have been performed on the value.</p>

The following XML child elements are specified for the MappingEntry element:

Element	Description
LinearTransformation / BooleanMappingTransformation / IntegerMappingTransformation / EnumerationMappingTransformation	Specifies an optional transformation for the mapping. If any, exactly one of these elements MUST be present to specify the type of the transformation. See Section 4.5.2 for details.

8. System Structure Signal Dictionaries (SSB)

A signal dictionary is a collection of signals defined through its DictionaryEntry elements.

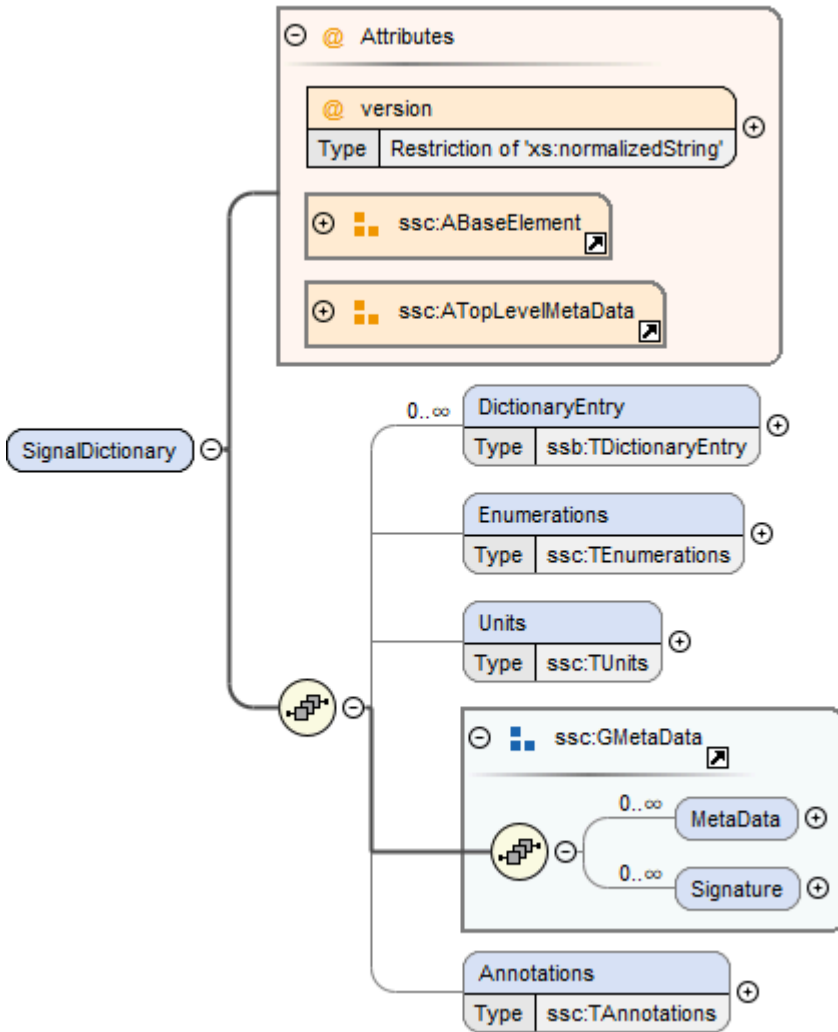
A signal dictionary can be provided either as a stand-alone XML file (an SSB file), which can be referenced from SSD files, or it can be embedded in an `ssd:SignalDictionary` element of the SSD directly (see Section 5.3.3).

An SSB file **MUST** be a well-formed XML 1.0 [XML10] file that conforms to the SystemStructureSignalDictionary XML Schema that is distributed as part of this standard. The file **MUST** use the UTF-8 encoding. All SSB-specific elements live in the `http://ssp-standard.org/SSP1/SystemStructureSignalDictionary` namespace, nicknamed `ssb`.

It is **RECOMMENDED** that the file extension `.ssb` be used for stand-alone SSB files. Except for this file extension recommendation the filename is arbitrary and is independent of variant handling or the names of SSD files.

The root element of an SSB file **MUST** be a `SignalDictionary` element, which contains an arbitrary number of `DictionaryEntry` elements. Any enumerations or units used in the `DictionaryEntry` elements **MUST** be declared within the `Enumerations` and `Units` child elements of the `SignalDictionary`.

8.1. SignalDictionary



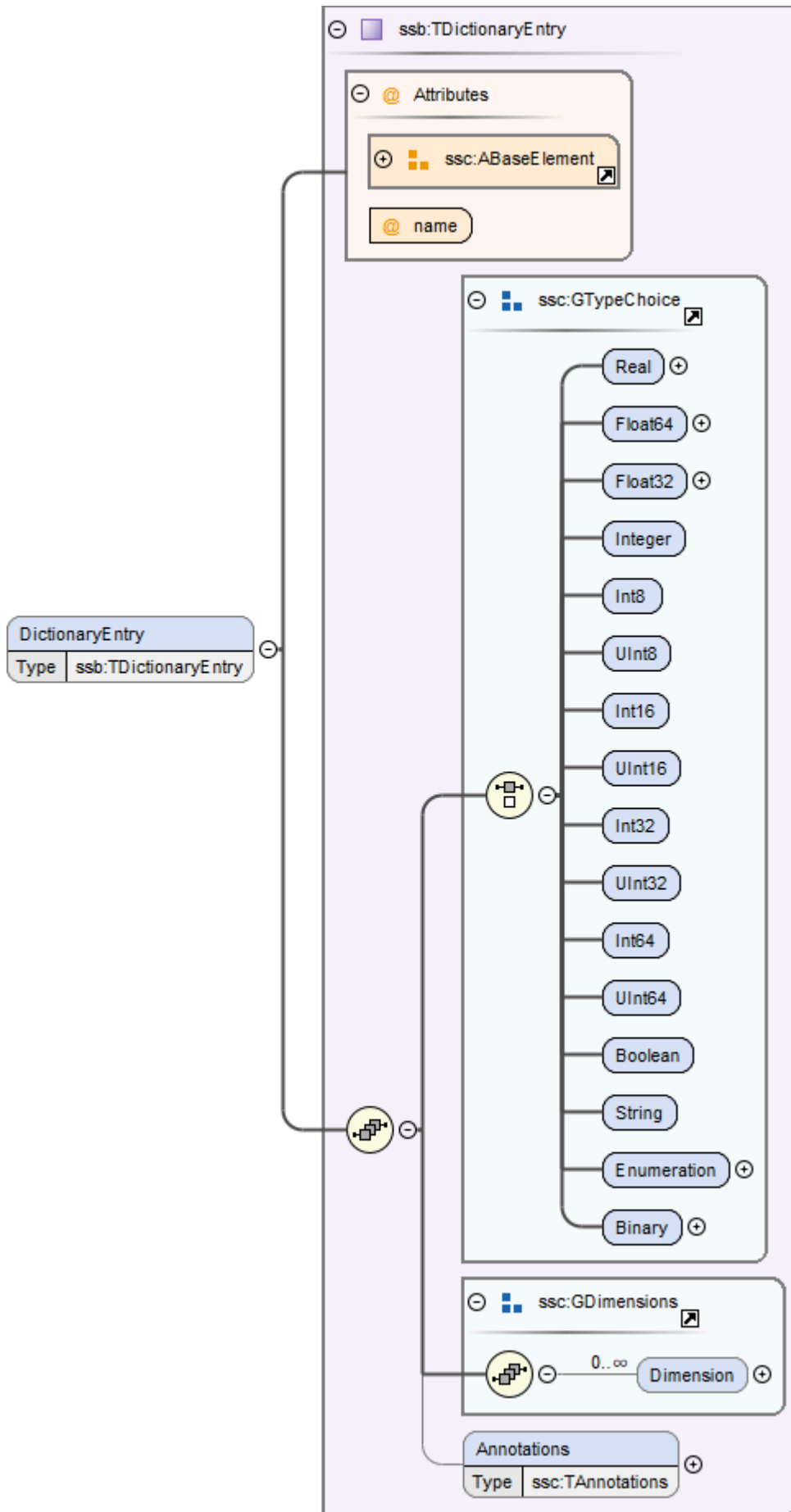
This element describes a signal dictionary, which consists of one or more dictionary entries, each describing one signal in the signal dictionary (see next section).

Attribute	Description
version	This required attribute specifies the version of this specification that the parameter mapping conforms to. Only major and minor version number are included, the patch version number MUST NOT be included in this attribute. For the current release this MUST be 1.0.

The following XML child elements are specified for the SignalDictionary element:

Element	Description	
DictionaryEntry	One or more entries of the signal dictionary.	
Enumerations	This optional element MUST contain definitions for all enumerations referenced in the signal dictionary.	
Units	This optional element MUST contain definitions for all units referenced in the signal dictionary.	

8.1.1. DictionaryEntry



A dictionary entry defines a single signal in the signal dictionary.

Attribute	Description
name	Required attribute giving the signal dictionary entry a name, which shall be unique within the signal dictionary.

The following XML child elements are specified for the DictionaryEntry element:

Element	Description
Real / Float64 / Float32 / Integer / Int8 / UInt8 / Int16 / UInt16 / Int32 / UInt32 / Int64 / UInt64 / Boolean / String / Enumeration / Binary	Exactly one of these elements MUST be present to specify the type of the signal dictionary entry. See Section 4.5.1 for details.
Dimension	One or more of these optional elements define the signal dictionary entry array dimensions, making the signal dictionary entry an array signal dictionary entry. See Section 4.5.3 for details.

9. Literature

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