Mapping SysML to RDF Vocabulary
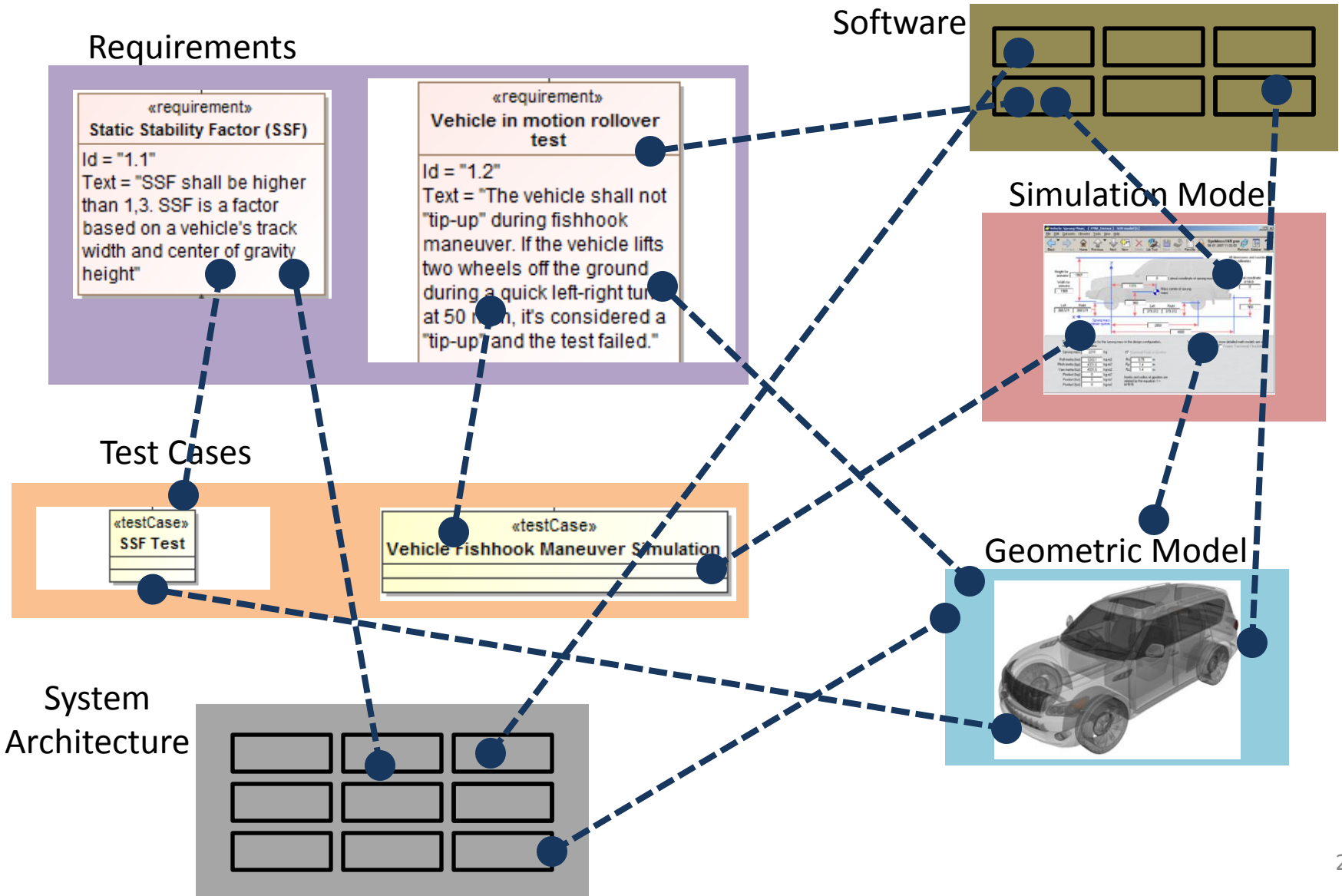
Axel Reichwein

April 28, 2014

Use Case Scenario:
Defining Relationships Between Engineering Data

Requirements

«requirement»
Static Stability Factor (SSF)

Id = "1.1"
Text = "SSF shall be higher than 1,3. SSF is a factor based on a vehicle's track width and center of gravity height"

«requirement»
Vehicle in motion rollover test

Id = "1.2"
Text = "The vehicle shall not "tip-up" during fishhook maneuver. If the vehicle lifts two wheels off the ground during a quick left-right turn at 50 m/h, it's considered a "tip-up" and the test failed."

Software

Simulation Model

Test Cases

«testCase»
SSF Test

«testCase»
Vehicle Fishhook Maneuver Simulation

Geometric Model

System Architecture

2

SysML Vocabulary

- **Purpose**:
  - Define SysML Data in RDF
  - Define relationships between resources using SysML terminology

- **Example** for expressing that a CAD Part satisfies a SysML Requirement:
  Given:

  | example:ReqA | rdf:type | sysml:Requirement |
  | example:PartA | rdf:type | cad:Part |

  Relationship can be expressed in two different ways:

  | example:PartA | oslc_rm:satisfies | example:ReqA |

example:Satisfies	rdf:type	sysml:Satisfy
example:Satisfies	sysml:Dependency_client	example:PartA
example:Satisfies	sysml:Dependency_supplier	example:ReqA

Generation of SysML Vocabulary

SysML.xmi

```xml
1  <?xml version="1.0" encoding="UTF-8"?>
2  <xmi:XMI xmlns:xmi="http://www.omg.org/spec/XMI/20110701"
3          xmlns:mofext="http://www.omg.org/spec/MOF/20110701"
4          xmlns:uml="http://www.omg.org/spec/UML/20110701"
5          xmlns:sysml="http://www.omg.org/spec/SysML/20120322/SysML">
6      <uml:Profile URI="http://www.omg.org/spec/SysML/20120322/SysML" xmi:type="uml:Profile"
7                  xmi:id="_SysML__0"
8                  name="SysML"
9                  visibility="public">
```

sysmlRDFVocabulary.rdf

```xml
1  <?xml version="1.0" encoding="UTF-8"?>
2  <rdf:RDF
3          xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
4          xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
5          xmlns:dcterms="http://purl.org/dc/terms/"
6          xmlns:uml="http://omg.org/spec/UML/2.4.1/"
7          xmlns:standardprofileL2="http://omg.org/spec/UML/StandardProfileL2/2.4.1/"
8          xmlns:sysml="http://omg.org/spec/SysML/1.3/">
```

SysML Vocabulary Generation Steps

1. One-to-one transformation
2. Making the generated SysML vocabulary an „open world" standard
3. Align the generated SysML vocabulary with other existing RDF vocabularies
4. Create version-independent SysML vocabulary and version-specific SysML vocabularies
5. Partition the generated SysML vocabulary into multiple smaller vocabularies that can evolve independently
6. Standardize SysML vocabulary(ies)

Mapping Imported Packages

- PackageImport => Reference to corresponding vocabulary namespace

Package Import


```
1   <?xml version="1.0" encoding="UTF-8"?>
2   <xmi:XMI xmlns:xmi="http://www.omg.org/spec/XMI/20110701"
3            xmlns:mofext="http://www.omg.org/spec/MOF/20110701"
4            xmlns:uml="http://www.omg.org/spec/UML/20110701"
5            xmlns:sysml="http://www.omg.org/spec/SysML/20120322/SysML">
6      <uml:Profile URI="http://www.omg.org/spec/SysML/20120322/SysML" xmi:type="uml:Profile"
7                   xmi:id="_SysML__0"
8                   name="SysML"
9                   visibility="public">
10       <metamodelReference xmi:idref="_SysML_packageImport__PackageImport._SysML__0._UML__0"/>
11       <packageImport xmi:type="uml:PackageImport"
12                      xmi:id="_SysML_packageImport__PackageImport._SysML__0._UML__0">
13           <importedPackage href="http://www.omg.org/spec/UML/20110701/UML.xmi#_0"/>
14       </packageImport>
15       <packageImport xmi:type="uml:PackageImport"
16                      xmi:id="_SysML_packageImport__PackageImport._SysML__0._StandardProfileL2__0">
17           <importedPackage href="http://www.omg.org/spec/UML/20110701/StandardProfileL2.xmi#_0"/>
18       </packageImport>
```

Namespace Declaration


```
1   <?xml version="1.0" encoding="UTF-8"?>
2   <rdf:RDF
3           xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
4           xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
5           xmlns:dcterms="http://purl.org/dc/terms/"
6           xmlns:uml="http://omg.org/spec/UML/2.4.1/"
7           xmlns:standardprofilel2="http://omg.org/spec/UML/StandardProfileL2/2.4.1/"
8           xmlns:sysml="http://omg.org/spec/SysML/1.3/">
```

Mapping Stereotypes

- uml:Stereotype => rdfs:Class
  - URI of rdfs:Class = namespace URI + uml:Stereotype name

- uml:Stereotype name => rdfs:label

Stereotype


```
<packagedElement xmi:type="uml:Stereotype"
                 xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FullPort_PackageableElement"
                 name="FullPort">
    <ownedAttribute xmi:type="uml:Property"
                    xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FullPort_PackageableElement-base_Port_Property"
                    name="base_Port"
                    visibility="public"
                    association="_SysML_Ports_u0026Flows_PackageableElement-E_base_Port_extension_FullPort_PackageableElement">
        <type href="http://www.omg.org/spec/UML/20110701/UML.xmi#Port"/>
    </ownedAttribute>
</packagedElement>
```

RDFS Class

sysmlRDFVocabulary.rdf

```
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/FullPort">
        <rdfs:label xml:lang="en-GB">FullPort</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
        <rdfs:subClassOf rdf:resource="uml:Port"/>
</rdfs:Class>
```

Mapping Stereotype Extension

- uml:Stereotype extension => rdfs:subClassOf

- Multiple uml:Stereotype extensions => Specific RDFS Class for each uml:Stereotype extension
  - An extension E from a stereotype S to an extended metaclass MC maps to "<MC.S> rdf:type rdfs:Class; <MC.S> rdfs:subClassOf <MC>; <MC.S> rdfs:subClassOf <S>"

Stereotype Extension


```
<packagedElement xmi:type="uml:Stereotype"
                 xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FullPort_PackageableElement"
                 name="FullPort">
   <ownedAttribute xmi:type="uml:Property"
                   xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FullPort_PackageableElement-base_Port_Property"
                   name="base_Port"
                   visibility="public"
                   association="_SysML_Ports_u0026Flows_PackageableElement-E_base_Port_extension_FullPort_PackageableElement">
      <type href="http://www.omg.org/spec/UML/20110701/UML.xmi#Port"/>
   </ownedAttribute>
</packagedElement>
```

rdfs:subClassOf Predicate

sysmlRDFVocabulary.rdf

```
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/FullPort">
        <rdfs:label xml:lang="en-GB">FullPort</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
        <rdfs:subClassOf rdf:resource="uml:Port"/>
</rdfs:Class>
```

Multiple Stereotype Extensions

```
<packagedElement xmi:type="uml:Stereotype"
                 xmi:id="_SysML_Activities_PackageableElement-Rate_PackageableElement"
                 name="Rate">
   <ownedAttribute xmi:type="uml:Property"
                   xmi:id="_SysML_Activities_PackageableElement-Rate_PackageableElement-rate_Property"
                   name="rate"
                   visibility="public">
      <type href="http://www.omg.org/spec/UML/20110701/UML.xmi#InstanceSpecification"/>
   </ownedAttribute>
   <ownedAttribute xmi:type="uml:Property"
                   xmi:id="_SysML_Activities_PackageableElement-Rate_PackageableElement-base_Parameter_Property"
                   name="base_Parameter"
                   visibility="public"
                   association="_SysML_Activities_PackageableElement-E_extension_Rate_base_Parameter_PackageableElement">
      <type href="http://www.omg.org/spec/UML/20110701/UML.xmi#Parameter"/>
   </ownedAttribute>
   <ownedAttribute xmi:type="uml:Property"
                   xmi:id="_SysML_Activities_PackageableElement-Rate_PackageableElement-base_ActivityEdge_Property"
                   name="base_ActivityEdge"
                   visibility="public"
                   association="_SysML_Activities_PackageableElement-E_extension_Rate_base_ActivityEdge_PackageableElement">
      <type href="http://www.omg.org/spec/UML/20110701/UML.xmi#ActivityEdge"/>
   </ownedAttribute>
</packagedElement>
```

Specific RDFS Class for each uml:Stereotype extension

```xml
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/Rate">
        <rdfs:label xml:lang="en-GB">Rate</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
</rdfs:Class>
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/Parameter.Rate">
        <rdfs:label xml:lang="en-GB">Rate</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
        <rdfs:subClassOf rdf:resource="uml:Parameter"/>
        <rdfs:subClassOf rdf:resource="sysml:Rate"/>
</rdfs:Class>
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/ActivityEdge.Rate">
        <rdfs:label xml:lang="en-GB">Rate</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
        <rdfs:subClassOf rdf:resource="uml:ActivityEdge"/>
        <rdfs:subClassOf rdf:resource="sysml:Rate"/>
</rdfs:Class>
```

Mapping Stereotype Generalization

- uml:Stereotype generalization => rdfs:subClassOf

Stereotype Generalization


```
<packagedElement xmi:type="uml:Stereotype"
                 xmi:id="_SysML_ConstraintBlocks_PackageableElement-ConstraintBlock_PackageableElement"
                 name="ConstraintBlock">
    <generalization xmi:type="uml:Generalization"
                    xmi:id="_SysML_ConstraintBlocks_PackageableElement-ConstraintBlock_PackageableElement-generalization__Gene
                    isSubstitutable="false"
                    general="_SysML_Blocks_PackageableElement-Block_PackageableElement"/>
</packagedElement>
```

rdfs:subClassOf Predicate

📄 sysmlRDFVocabulary.rdf

```
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/ConstraintBlock">
        <rdfs:label xml:lang="en-GB">ConstraintBlock</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
        <rdfs:subClassOf rdf:resource="sysml:Block"/>
</rdfs:Class>
```

Additional Predicates

- rdfs:definedBy (reference to SysML vocabulary)
- dcterms:issued (date)

Additional Predicates

📄 sysmlRDFVocabulary.rdf

```
<rdfs:Class rdf:about="http://omg.org/spec/SysML/1.3/FullPort">
        <rdfs:label xml:lang="en-GB">FullPort</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
        <rdfs:subClassOf rdf:resource="uml:Port"/>
</rdfs:Class>
```

Mapping Stereotype Owned Attributes

- uml:Stereotype owned attribute => rdf:property
  - URI of rdf:Property = namespace URI + uml:Stereotype name + „_" + owned attribute name

- uml:Stereotype owned attribute name => rdfs:label

- Additional predicates:
  - rdfs:definedBy (reference to SysML vocabulary)
  - dcterms:issued (date)

Stereotype Owned Attribute


```xml
<packagedElement xmi:type="uml:Stereotype"
            xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FlowProperty_PackageableElement"
            name="FlowProperty">
    <ownedAttribute xmi:type="uml:Property"
            xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FlowProperty_PackageableElement-direction_Property"
            name="direction"
            visibility="public"
            type="_SysML_Ports_u0026Flows_PackageableElement-FlowDirection_PackageableElement"/>
    <ownedAttribute xmi:type="uml:Property"
            xmi:id="_SysML_Ports_u0026Flows_PackageableElement-FlowProperty_PackageableElement-base_Property_Property"
            name="base_Property"
            visibility="public"
            association="_SysML_Ports_u0026Flows_PackageableElement-E_base_Property_extension_FlowProperty_PackageableE
        <type href="http://www.omg.org/spec/UML/20110701/UML.xmi#Property"/>
    </ownedAttribute>
</packagedElement>
```

RDF Property

sysmlRDFVocabulary.rdf

```
<rdf:Property rdf:about="http://omg.org/spec/SysML/1.3/FlowProperty_direction">
        <rdfs:label xml:lang="en-GB">direction</rdfs:label>
        <rdfs:isDefinedBy rdf:resource="http://omg.org/spec/SysML/1.3/"/>
        <dcterms:issued>2014-April-04</dcterms:issued>
</rdf:Property>
```

SysML-Related Vocabularies

- SysML extends UML
- SysML refers to UML Standard Profile L2

- Creation of SysML-Related Vocabularies for:
  - UML
  - UML Standard Profile L2

- Alternative: SysML as standalone vocabulary

Generation of UML Vocabulary

- uml:metaclass => rdfs:Class (same rules as for uml:stereotype)

- Not mapping following UML elements into UML vocabulary:
  - uml:Association (CMOF-specific issue + no associations in RDFS)
  - uml:DataType (no rdfs:range relations)
  - uml:Enumeration (no rdfs:range relations)

SysML Vocabulary Namespace URI

- Namespace URI: **http://www.omg.org/spec/SysML/1.3/**

- Rationale: Best practice is to have a single URI for a concept and publish different representations through content negotiation, as with the Dublin Core vocabulary, or as with OSLC vocabularies.

- Current proposal: Same URI as HTML representation of SysML standard (http://www.omg.org/spec/SysML/1.3/)

- Alternative: define a different namespace URI, and do a redirect to http://www.omg.org/spec/SysML/1.3/ for accessing the HTML representation

SysML Vocabulary Namespace URI


```
1   <?xml version="1.0" encoding="UTF-8"?>
2   <rdf:RDF
3        xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
4        xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
5        xmlns:dcterms="http://purl.org/dc/terms/"
6        xmlns:uml="http://omg.org/spec/UML/2.4.1/"
7        xmlns:standardprofilel2="http://omg.org/spec/UML/StandardProfileL2/2.4.1/"
8        xmlns:sysml="http://omg.org/spec/SysML/1.3/">
```

Any Questions?

Contact me at axel.reichwein@koneksys.com