

Bidirectional SysML V1 to AADL Bridge

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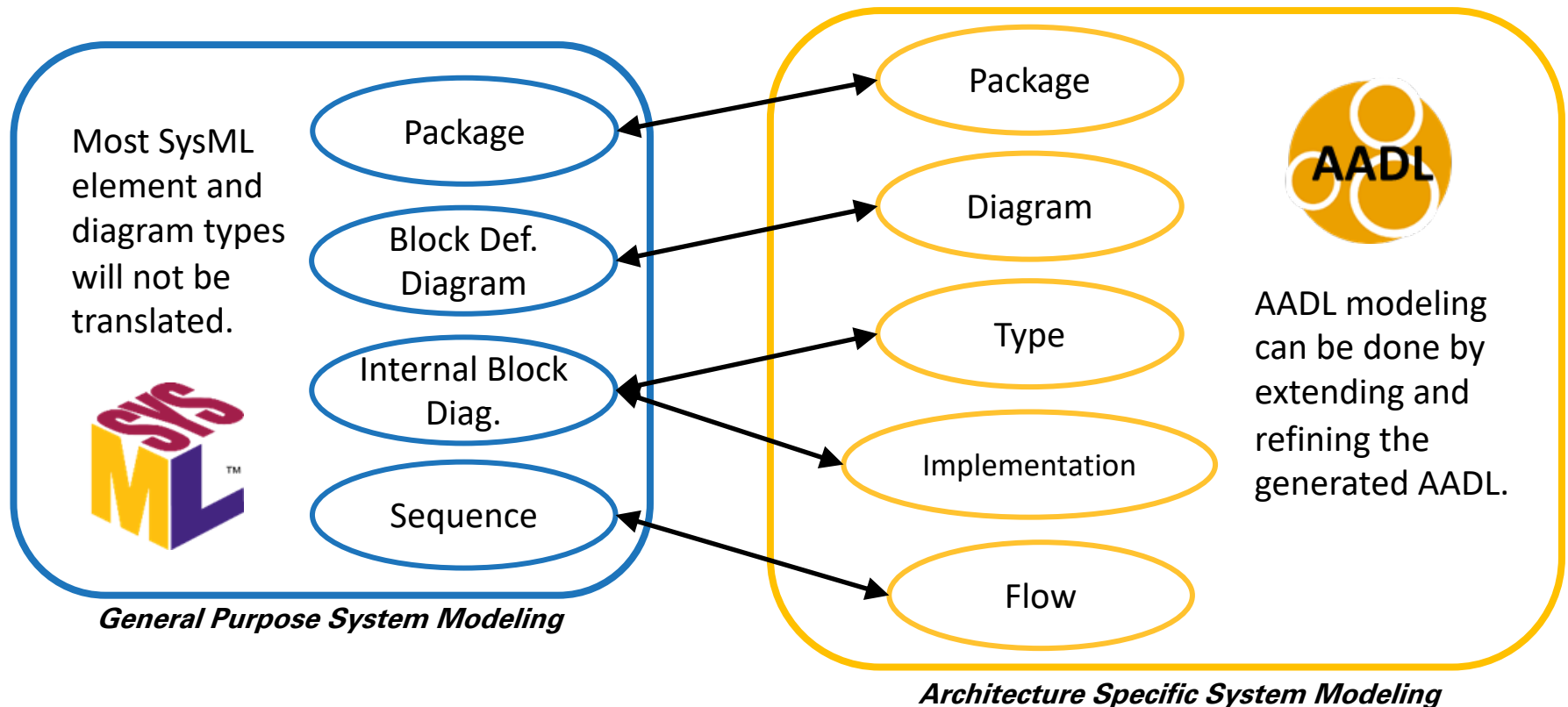
August Schwerdfeger

Agenda

- Design goals
- Supported workflows
 - Analysis and round-trip engineering
 - Model refinement & integration
- SysML V1 to AADL
 - AADL Profile
 - Usage Details
- AADL to SysML V1
 - Generated Diagram Types
 - Usage Details
- Questions

Targeted Portions of SysML Only

- Allow users to annotate portions of SysML models using an AADL Profile and automatically translate such portions into AADL.



Clear Semantics

- Transition SysML specification from system engineering phase of development into standardized AADL semantics for ACVIP/AADL virtual integration analysis.
- Provide a common (across multiple programs, contractors) AADL Profile based on the AADL standard that is amenable to extension for additional AADL properties and annexes (for integration of additional analysis tools).

Provided SysML AADL Profiles:

- Core AADL stereotypes and properties
- Extension profiles for ARINC 653, Base Types, Data Model, FASTAR, GUMBO, MADS, MILS, RMF, SEI, SESSAF (STPA),

MagicDraw/Cameo Enterprise Architecture and Sparx Enterprise Architect

Modeling Style Support

- SysML standards and conventions, natural for SysML aficionados.
- AADL standards and conventions, natural for AADL aficionados.
- Clear mapping from stereotyped SysML elements with tagged value properties to the AADL generated from those elements and properties.

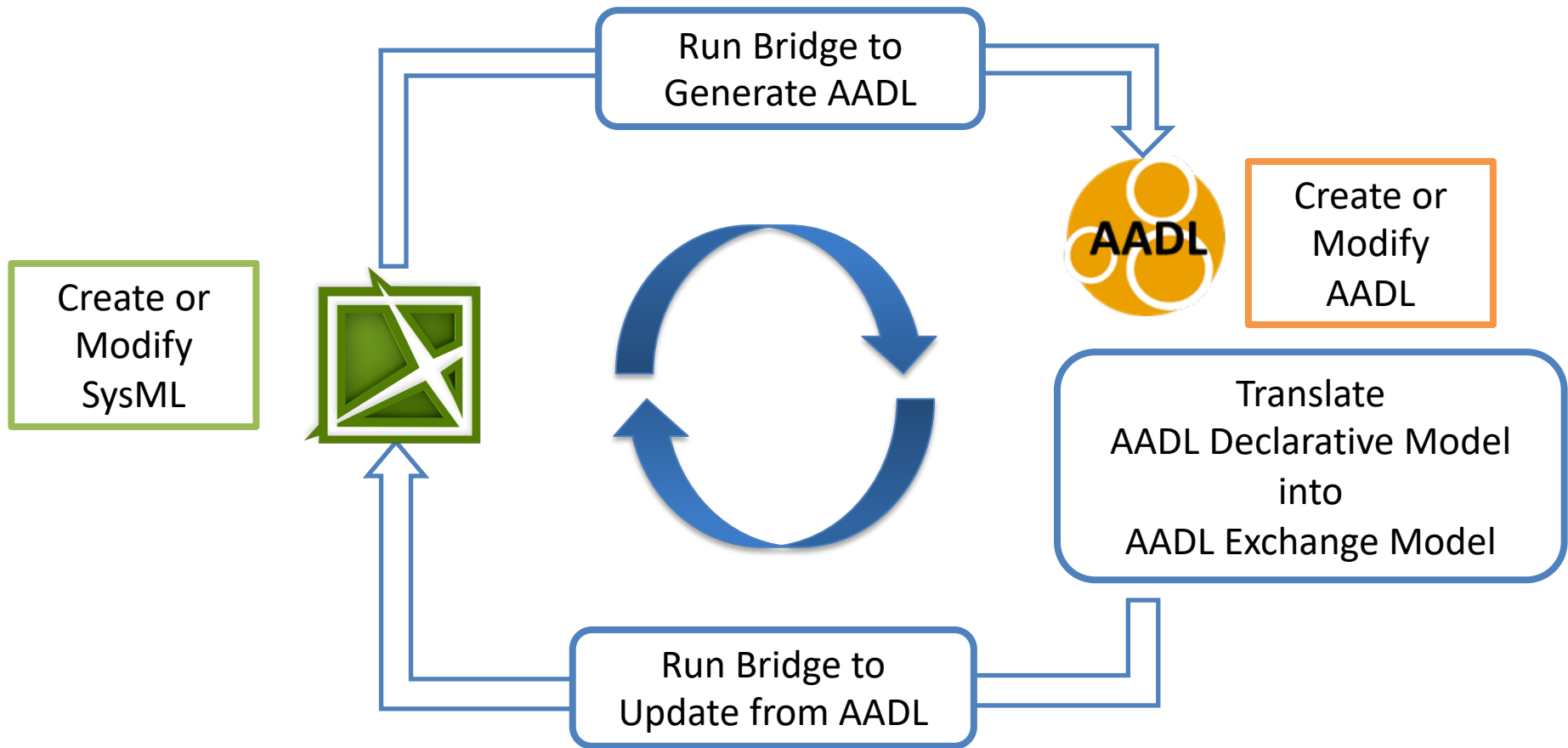
Provided Documentation:

- SysML AADL Profile and Modeling Guidelines
- SysML example models

Agenda

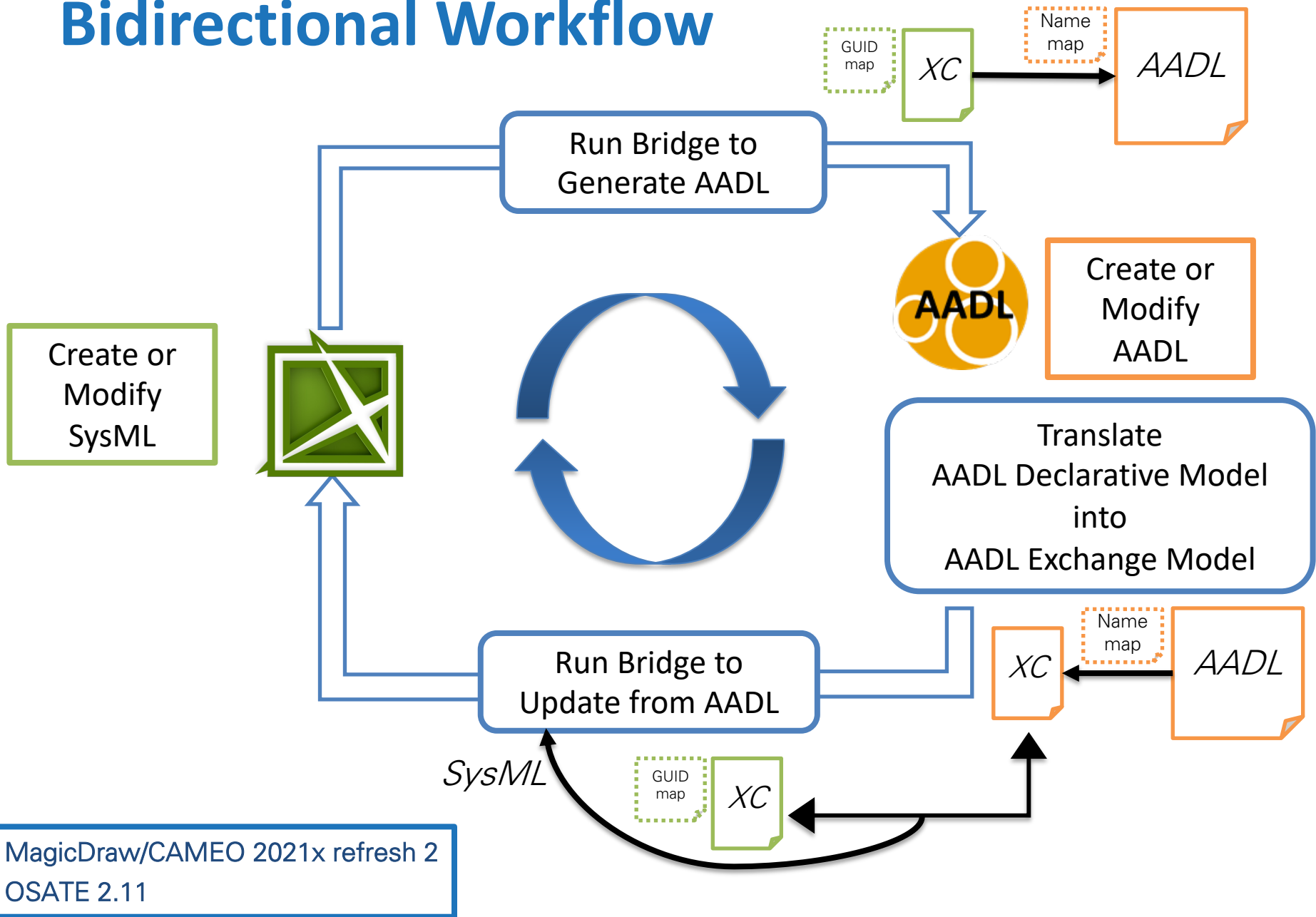
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Bidirectional Workflow



MagicDraw/CAMEO 2021x refresh 2
OSATE 2.11

Bidirectional Workflow



MagicDraw/CAMEO 2021x refresh 2
OSATE 2.11

Exchange Model

Independent of OSATE object model

Easily changed/manipulated

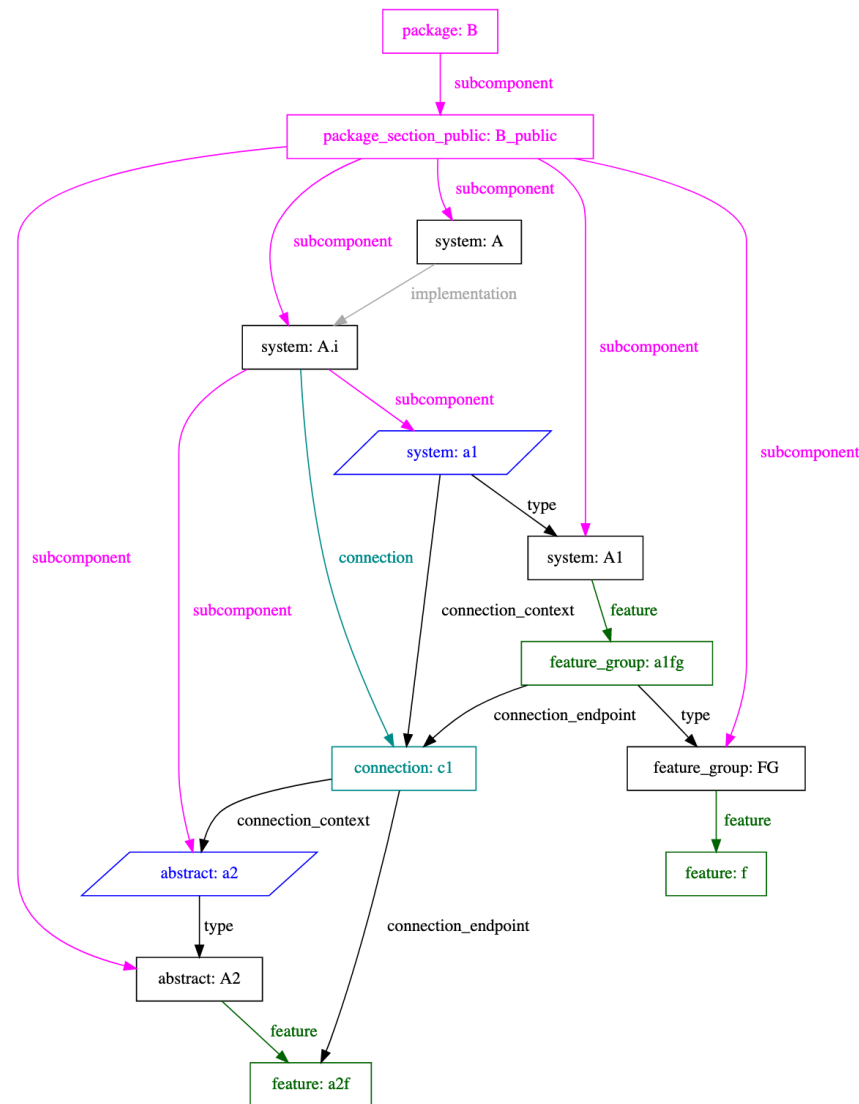
Flat graph representation

Current Representations

- xml schema
- Java/JAXB
- Typescript
- Python/Django

Current Projects

- SysML V1 to AADL Bridge translator
- MAUDE (Model-based Analysis using Domaine Expertise)
- SEDS (SAVOIR Electronic Data Sheet) Import/Export Tool
- Query Language for detailed/aggregated measurements

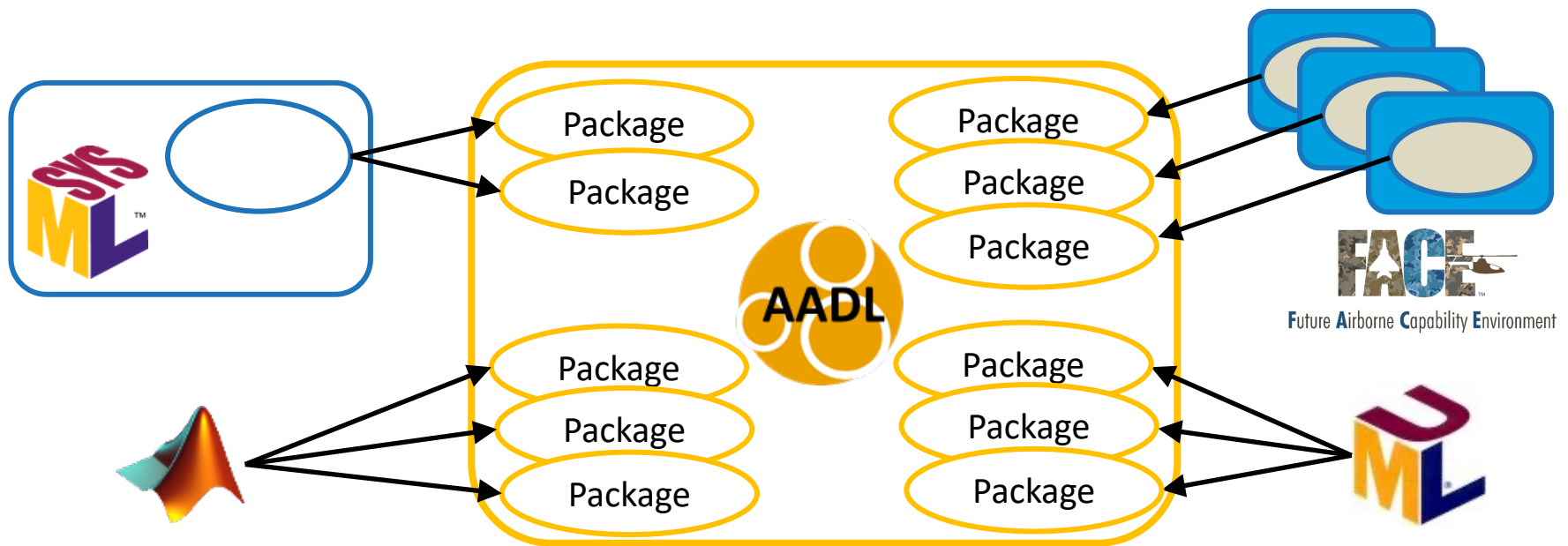


Round-trip Engineering

- Generation or creation of AADL project.
- Run analysis in OSATE.
- Make additions/refinements in AADL.
- Update SysML model to bring in changes.
- Validate SysML in CAMEO/MagicDraw.
- Make additions/modification of SysML.
- Generation of AADL project (and repeat).

Virtual Integration

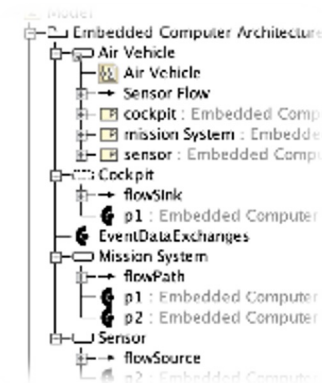
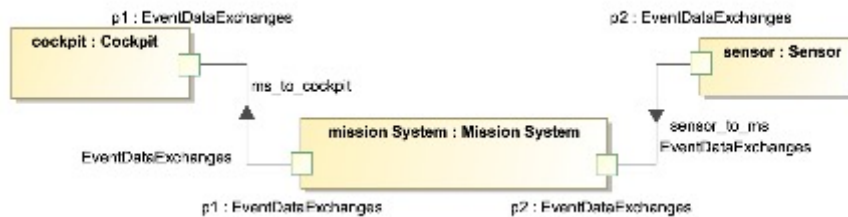
- Virtual integration of computer system architecture model occurs in an AADL modeling environment.
- Modularized, textual, BNF-based exchange formats have been proven very useful for model exchange and configuration management.



Split Between SysML & AADL



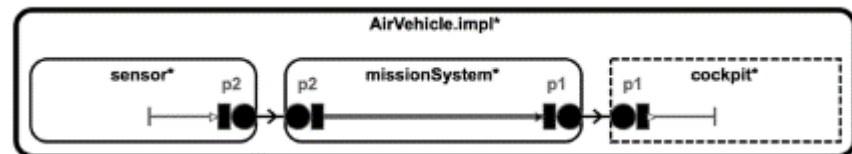
- Detailed AADL Analysis: where should additional property values and model details be added?
 - **Option 1:** Expand SysML model with refinements, new components, new tags/properties.



- **Option 2:** Refine generated AADL model.

```

-- from SysML Air Vehicle (_19_0_2_c3f0303_1587146874690_365944_426)
system implementation AirVehicle.inpl
subcomponents
  cockpit: abstract Cockpit; -- from SysML cockpit (_19_0_2_c3f0303_1587146874690_365944_426)
  missionSystem: system MissionSystem; -- from SysML mission System (_19_0_2_c3f0303_1587146874690_365944_426)
  sensor: system Sensor; -- from SysML sensor (_19_0_2_c3f0303_1587146874690_365944_426)
connections
  mstocockpit: feature group missionSystem.p1 -> cockpit.p1;
  sensortans: feature group sensor.p2 -> missionSystem.p2; --
flows
  SensorFlow: end to end flow
  sensor.flowSource ->
  sensortans ->
  missionSystem.flowPath ->
  mstocockpit ->
  cockpit.flowSink; -- from SysML Sensor Flow (_19_0_3_31c)
properties
  Latency => 100 ns .. 175 ns applies to SensorFlow;
end AirVehicle.inpl;
    
```



Option 1. SysML Refinement

Example of use: Want to provide the property at the SysML level.

- Generalization/Inheritance refinement all supported by the translator.
- Create custom profiles for a missing AADL Property Sets.
 - Detailed instructions in provided documentation.
 - Any tag defined in a profile named “AADL_<something>_Profile” will be translated into an AADL property if a SysML model element has that tag.

Provided Example Model:

- Architecture_Refinement_Example

Provided SysML AADL Profiles:

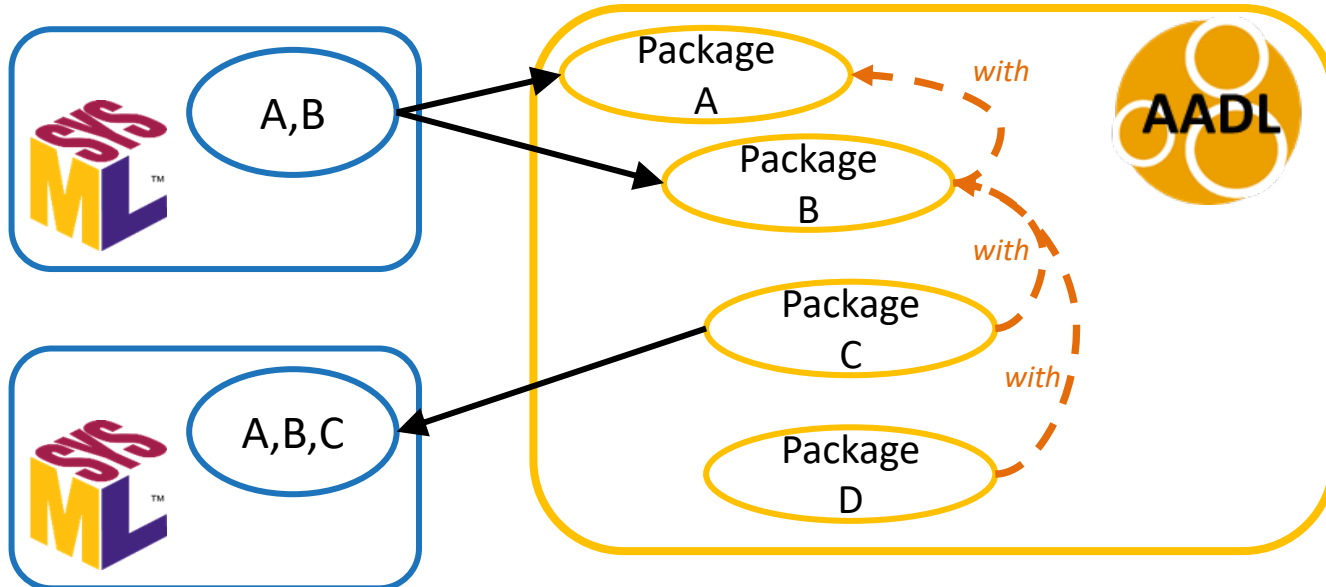
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MagicDraw/Cameo Enterprise Architecture and Sparx Enterprise Architect

Option 2. AADL Refinement

Example of use: Complex properties defined during the embedded design phase with added analyses as the fidelity of the model increases.

- For example, refining a generated AADL component to include Error Modeling using EMV2 annex.
- Only the selected package and any nested *with* packages will be translated.



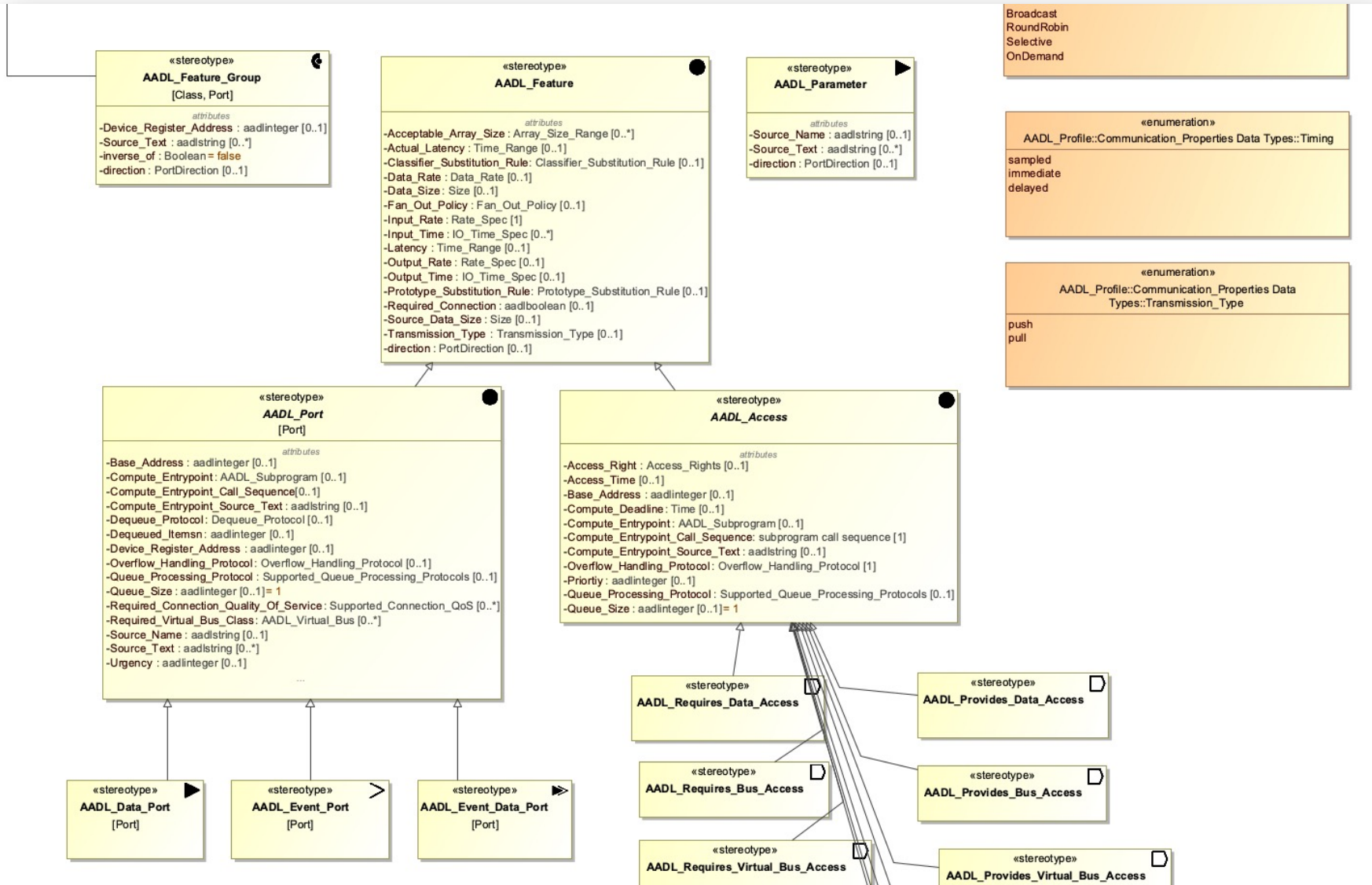
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SysML V1 to AADL Supported Features

- Names and Name Spaces via Packages
- Types and Implementations via Blocks/Block Definition Diagrams
 - Extensions via Generalization Relations
 - Subcomponents via Aggregation or Composition Relations
- Ports, Features, and Connections via Internal Block Diagrams
- Properties via Tagged Values
- Binding Relations via Allocations
- Flows via Interactions/Sequence Diagrams
 - Source, Sink, Path and End to End
- Annex Profiles for limited Annexes

AADL Profile (excerpt)

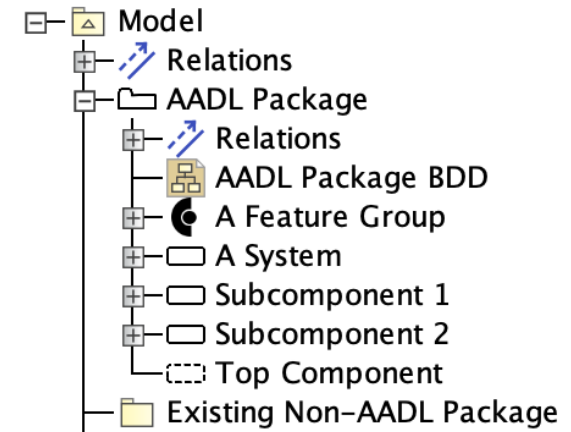
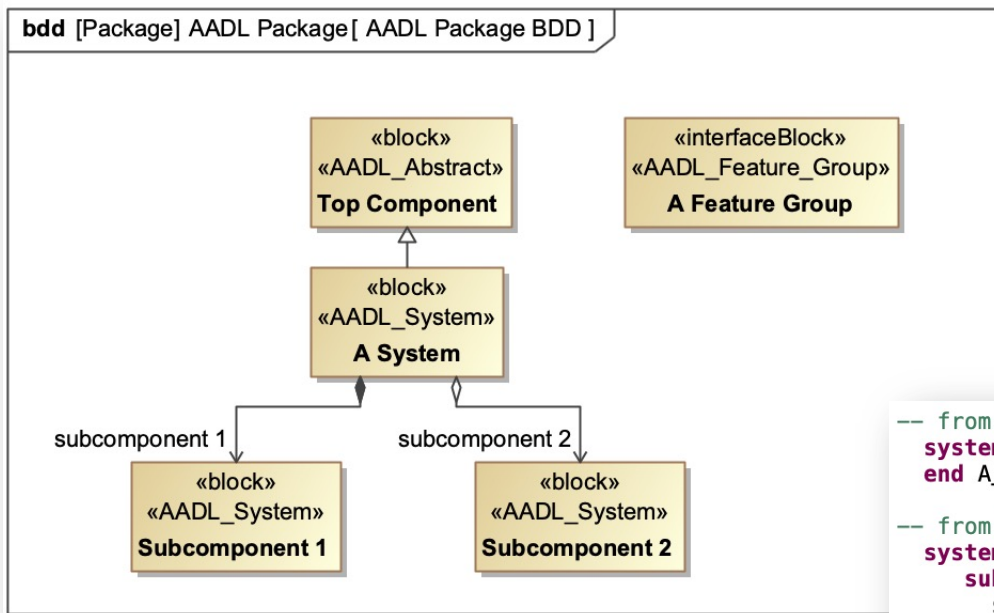


Mapping of Core AADL Stereotypes (Excerpt from Modeling Guidelines)

AADL stereotype	SysML element	Generated AADL declaration(s)	AS5506C
AADL_Package	package	package in a file	4.2
AADL_Abstract	block	abstract type + implementation	4.6
AADL_Data	block	data type + implementation	5.1
AADL_Subprogram	block	subprogram type + implementation	5.2
AADL_Thread	block	thread type + implementation	5.3
AADL_Thread_Group	block	thread group type + implementation	5.4
AADL_Process	block	process type + implementation	5.5
AADL_Processor	block	processor type + implementation	6.1
AADL_Virtual_Processor	block	virtual processor type + implementation	6.2
AADL_Memory	block	memory type + implementation	6.3
AADL_Bus	block	bus type + implementation	6.4
AADL_Virtual_Bus	block	virtual bus type + implementation	6.5
AADL_Device	block	device type + implementation	6.6
AADL_System	block	system type + implementation	7.1
AADL_Feature	port	feature (in a type declaration)	8.1
AADL_Feature_Group	port	feature group (in a type declaration)	8.2
AADL_Feature_Group	interfaceBlock	feature group type + implementation	8.2
AADL_Access	port	provides/requires access (in a type declaration)	8.6-8.8
AADL_Flow	interaction	flow source, path, sink, end-to-end	10

Selecting Elements for Translation

- Using AADL Profile to select Packages and Components for translation.
- Annotating the Block Definition Diagram.



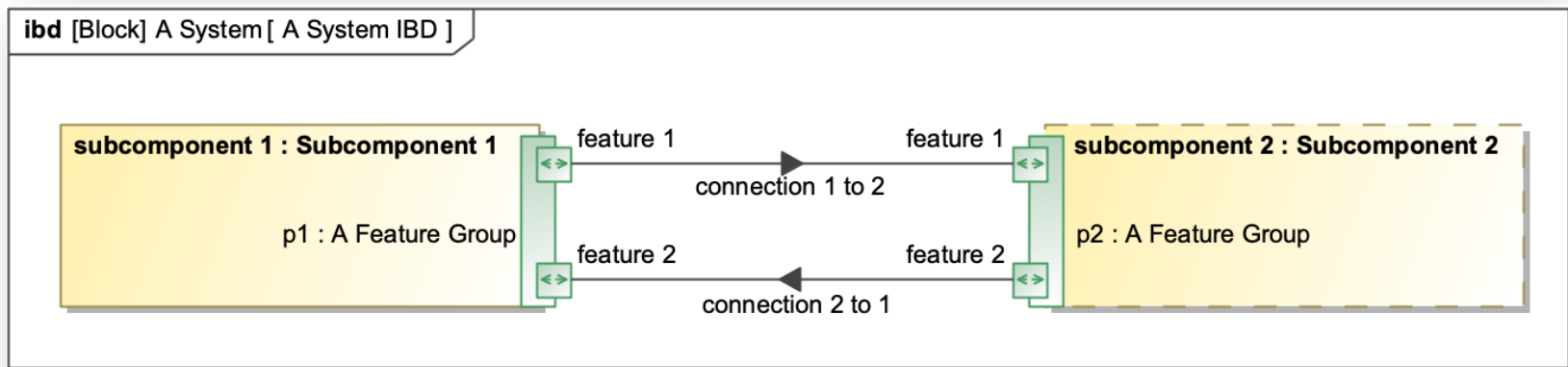
```

-- from SysML A System (_2021x_2_1b400495_1686756753980_168439
system A_System extends Top_Component
end A_System;

-- from SysML A System (_2021x_2_1b400495_1686756753980_168439
system implementation A_System.impl
subcomponents
  subcomponent_1 : system Subcomponent_1; -- from SysML s
  subcomponent_2 : system Subcomponent_2; -- from SysML s
end A_System.impl;
  
```

Ports and Connections

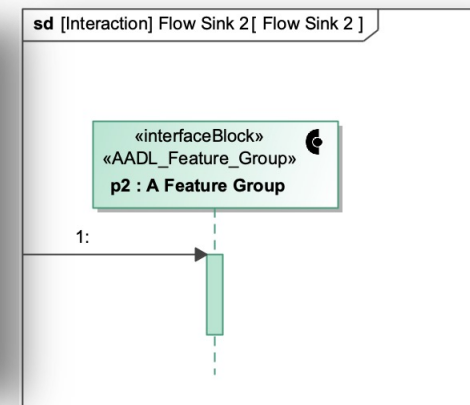
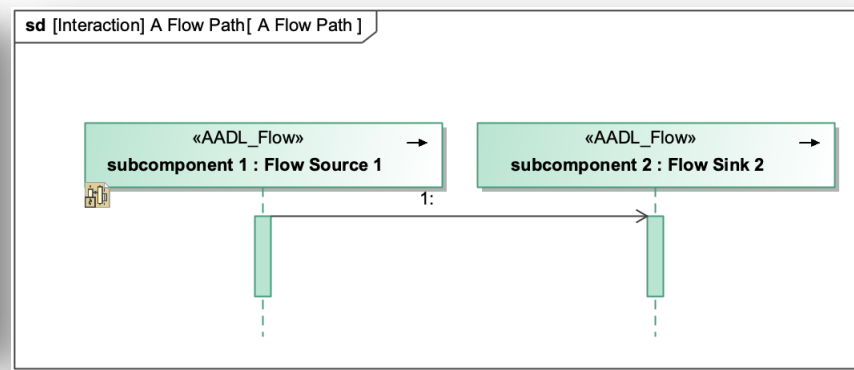
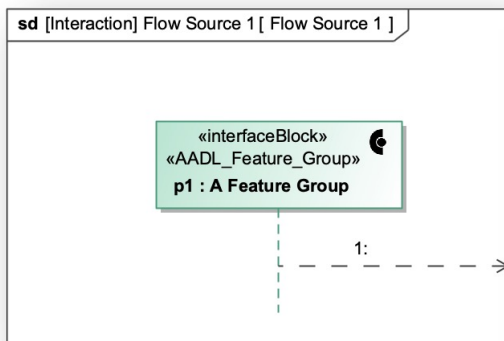
- Adding ports and connections.
- Annotating the Internal Block Diagram.
- Setting direction on connections.



```
-- from SysML A System (_2021x_2_1b400495_1686756753980_168439_2919)
system implementation A_System.impl
  subcomponents
    subcomponent_1 : system Subcomponent_1; -- from SysML subcomponent 1 (_2021x_2_1b400495_1686756848813_865118_3021)
    subcomponent_2 : system Subcomponent_2; -- from SysML subcomponent 2 (_2021x_2_1b400495_1686756857313_973638_3036)
  connections
    connection_1_to_2 : feature subcomponent_1.p1.feature_1 -> subcomponent_2.p2.feature_1; -- from SysML connection 1
    connection_2_to_1 : feature subcomponent_2.p2.feature_2 -> subcomponent_1.p1.feature_2; -- from SysML connection 2
end A_System.impl;
```

Adding End-to-End Flow

- Creating sequence diagrams to add a source flow, a sink flow and an end to end flow through components.



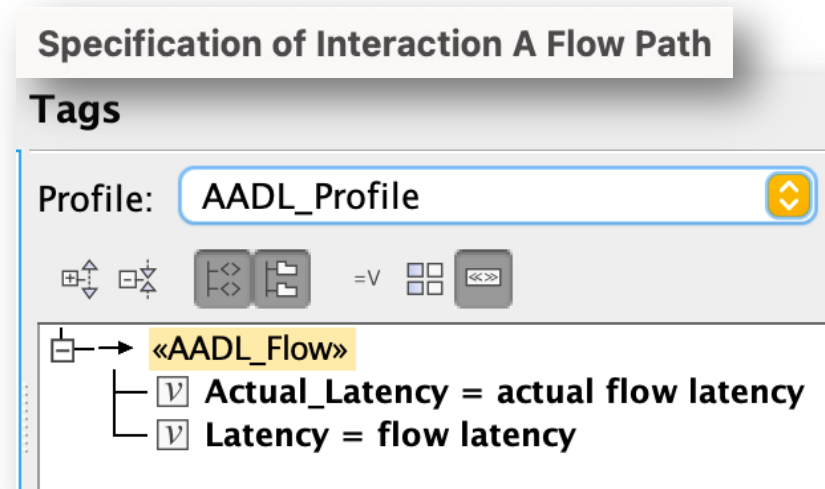
```

-- from SysML A System (_2021x_2_1b400495_1686756753980_168439_2919)
system implementation A_System.impl
  subcomponents
    subcomponent_1 : system Subcomponent_1; -- from SysML subcomponent 1 (_2021x_2_1b400495_1686756848813_865118_3021)
    subcomponent_2 : system Subcomponent_2; -- from SysML subcomponent 2 (_2021x_2_1b400495_1686756857313_973638_3036)
  connections
    connection_1_to_2 : feature subcomponent_1.p1.feature_1 -> subcomponent_2.p2.feature_1; -- from SysML connection 1 to 2 (_2021x_2_1b400495_1686756857313_973638_3036)
    connection_2_to_1 : feature subcomponent_2.p2.feature_2 -> subcomponent_1.p1.feature_2; -- from SysML connection 2 to 1 (_2021x_2_1b400495_1686756857313_973638_3036)
  flows
    A_Flow_Path : end to end flow subcomponent_1.Flow_Source_1 -> connection_1_to_2 -> subcomponent_2.Flow_Sink_2; -- from SysML flow A_Flow_Path (_2021x_2_1b400495_1686756857313_973638_3036)
end A_System.impl;

```

Annotating with Tag Values (Part 1/2)

- Properties as tagged values on stereotyped elements.



properties

Actual_Latency => 2 ms .. 3 ms **applies to** A_Flow_Path; -- from SysML Element Tagged Value (_2021x_2_1b400495_1686761585938_3)
Latency => 1 ms .. 4 ms **applies to** A_Flow_Path; -- from SysML Element Tagged Value (_2021x_2_1b400495_1686760249827_982656_4)

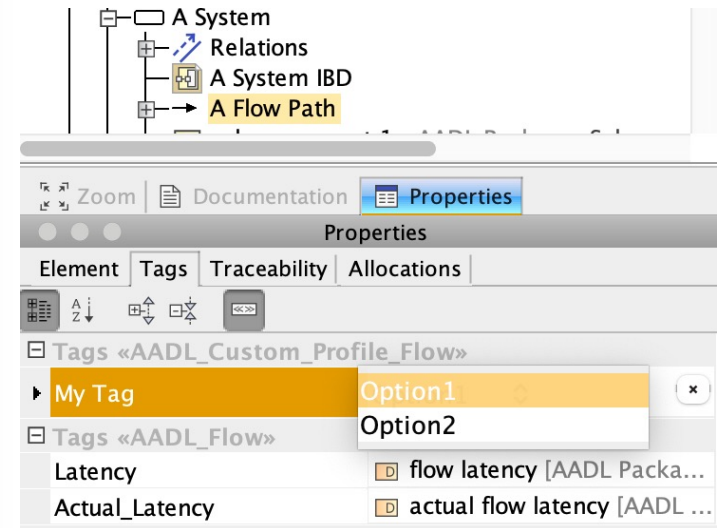
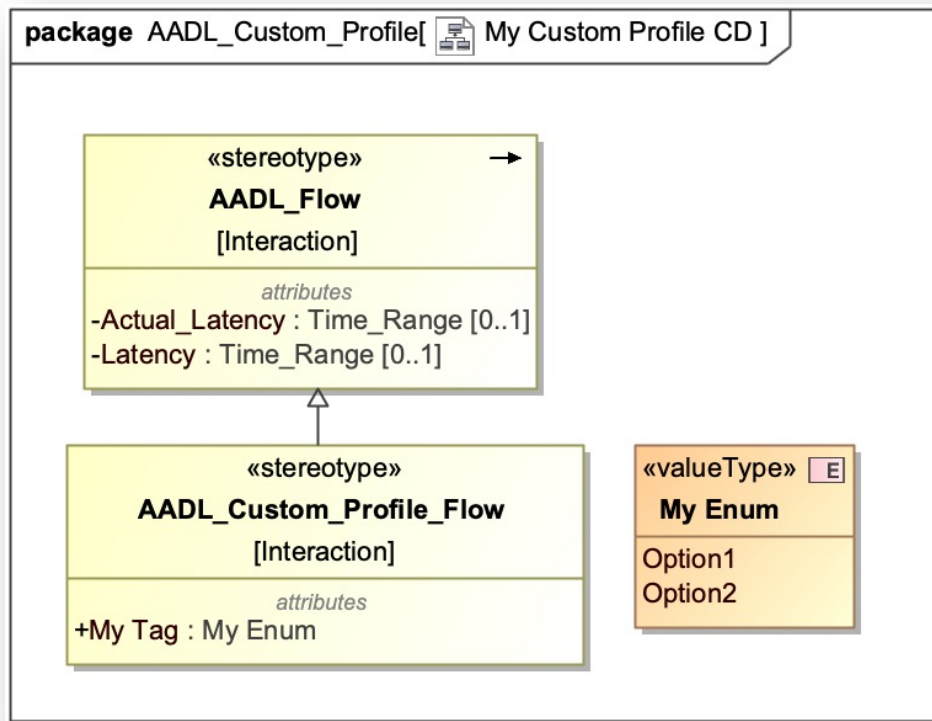
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Annotating with Tag Values (part 2/2)

- Implementing an Extension Profile for a custom Property Sets.



properties

```
Actual_Latency => 2 ms .. 3 ms applies to A_Flow_Path; -- from SysML Element Tagged Value (_2021x_2_1b400495_1680)
Latency => 1 ms .. 4 ms applies to A_Flow_Path; -- from SysML Element Tagged Value (_2021x_2_1b400495_1680)
Custom::My_Tag => Option1 applies to A_Flow_Path; -- from SysML Element Tagged Value (_2021x_2_1b400495_1680)
```

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AADL to SysML v1 Supported Features

Packages

Components/Implementations (Blocks)

Feature Group Definitions (Interface Block)

Features (Ports)

Direction

Type

Ends

Connections

Direction

Ends

Subcomponents (Parts)

Type

Flows (Sequences)

Flow Elements

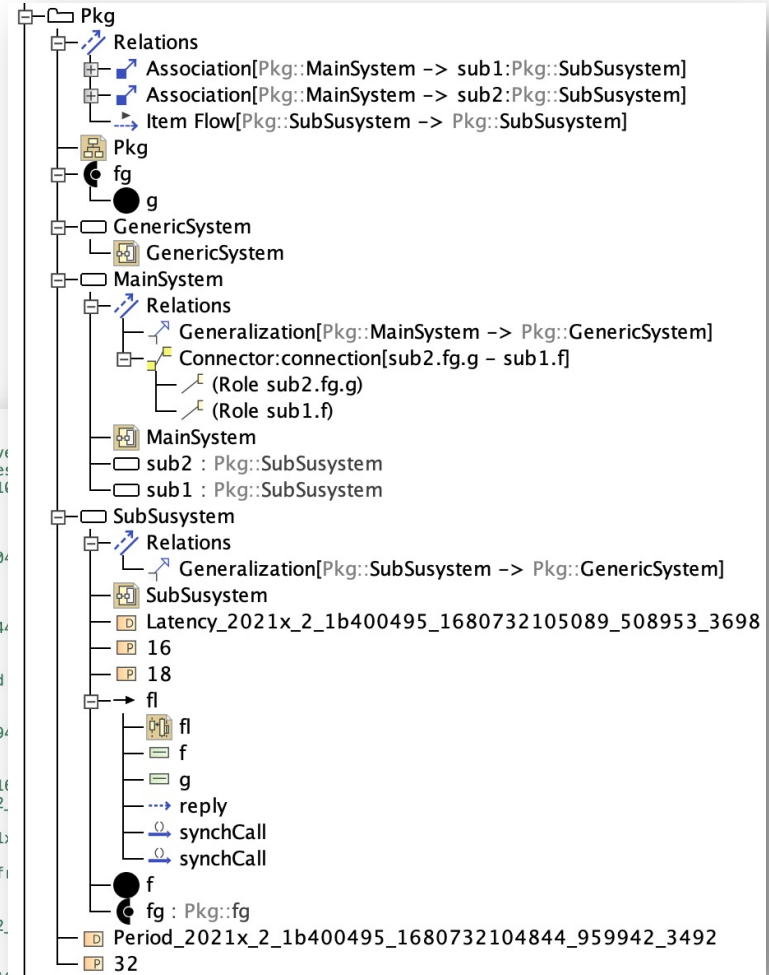
Properties (Tags)

Values, Ranges

Units

Bindings (Allocates)

```
-- Generated from XML by AADLXTextTranslator
-- GENERATED FILE by MagicDraw SysML to AADL Bridge (dev)
-- from SysML file: /Users/hshackleton/Desktop/Testing/Te
-- from SysML MD package: Pkg (_2021x_2_1b400495_16807321
package Pkg
public
-- from SysML GenericSystem (_2021x_2_1b400495_168073210
system GenericSystem
end GenericSystem;
-- from SysML MainSystem (_2021x_2_1b400495_168073210484
system MainSystem extends GenericSystem
properties
Period => 32 ms; -- from SysML Element Tagged
end MainSystem;
-- from SysML SubSubsystem (_2021x_2_1b400495_16807321049
system SubSubsystem extends GenericSystem
features
f : feature; -- from SysML f (_2021x_2_1b400495_1f
fg : feature group fg; -- from SysML fg (_2021x_2
flows
fl : flow path f -> fg.g; -- from SysML fl (_2021
properties
Latency => 16 ms .. 18 ms applies to fl; -- f
end SubSubsystem;
-- from SysML fg (_2021x_2_1b400495_1680732105043_746722
feature group fg
features
g : feature; -- from SysML g (_2021x_2_1b400495_1680732105043_746722
end fg;
-- from SysML MainSystem (_2021x_2_1b400495_1680732104844_959942_3492)
system implementation MainSystem.impl
subcomponents
sub2 : system SubSubsystem; -- from SysML sub2 (_2021x_2_1b400495_1680732105057_676481_3635)
sub1 : system SubSubsystem; -- from SysML sub1 (_2021x_2_1b400495_1680732105070_562645_3658)
connections
connection : feature sub2.fg.g -> sub1.f; -- from SysML connection (_2021x_2_1b400495_1680732105082_617032
end MainSystem.impl;
end Pkg;
```



Generated SysML V1 Diagrams

Block Definition Diagrams

For each Package

- Blocks
- Generalizations
- Parts

Internal Block Diagrams

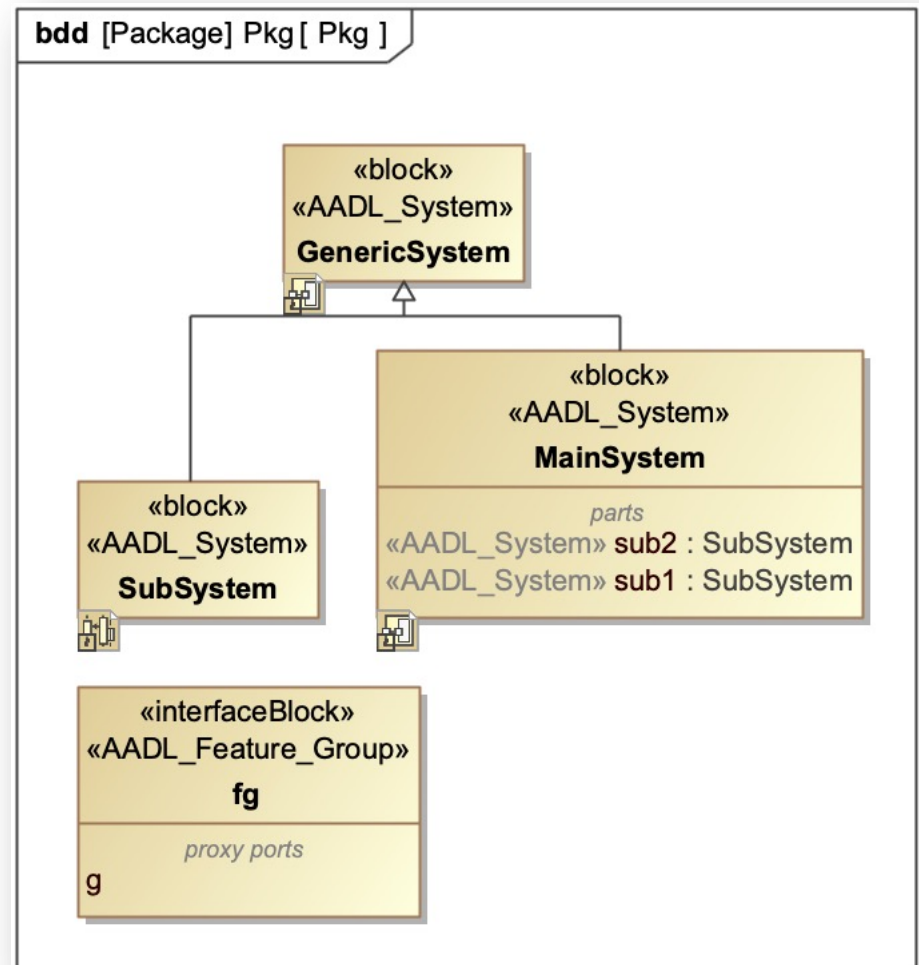
For each Component

- Parts
- Ports
- Connections/Flows

Sequence Diagrams

For each Flow

- Lifelines (Flows or Ports)
- Messages



Generated SysML V1 Diagrams

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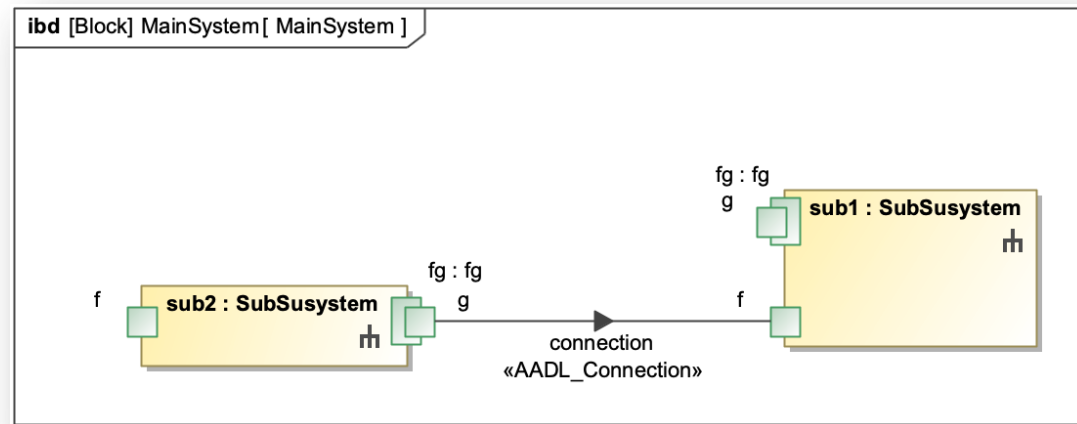
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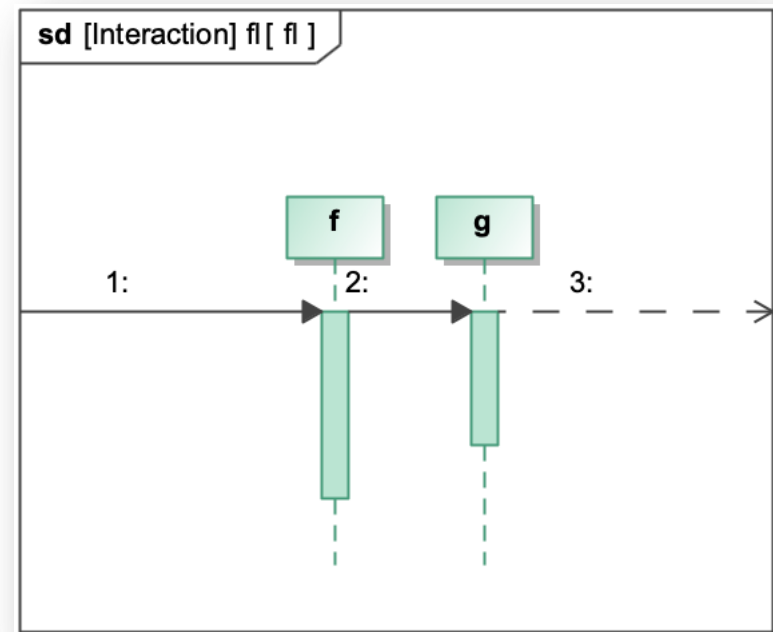
For each Component

- Parts
- Ports
- Connections/Flows

Sequence Diagrams

For each Flow

- Lifelines (Flows or Ports)
- Messages



Current Limitations of AADL to SysML V1

AADL Element changes that can NOT be updated in SysML

- Comments

- Annexes*

- Multiple implementations on a single type

- Refinement of properties/flows on implementations

- Names of elements

SysML Notes

- All necessary profiles must be loaded prior to update

- After updating from AADL, generate AADL from the updated model
before making other AADL changes

Deletion: Our general practice is NOT to delete things from SysML. If elements are deleted in AADL they will NOT be deleted in SysML at this time.

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➤ Questions

Quick Shout Out / Thank you

- The initial work and plan was accomplished with oversight by a SysML AADL Working Group consisting consisting of Army Aviation system integrators and suppliers.
- Other work we looked at:
 - MARTE
 - Open Archive Toulouse Archive Ouverte (OATAO)
 - ExSAM Profile, 2011 (University of Oslo, Norway)
 - SCADE Architect to AADL translator
 - Rockwell Collins SysML to AADL translator v1.1 2016
 - SLICED AADL Profile for UML state machine diagrams

Questions?

www.camet-library.com

Documentation

- SysML AADL Profile and Modeling Guidelines
- SysML example models

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