

An Overview of the SysML-Modelica Transformation Specification

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SysML-Modelica Transformation Specification: Context & Objective



- Two complementary languages for Systems Engineering:
 - Descriptive modeling in SysML
 - Formal equation-based modeling for analyses and trade studies in Modelica

- Objective:
 - Leverage the strengths of both SysML and Modelica by integrating them to create a more expressive and formal MBSE language.
 - Define a formal Transformation Specification:
 - a SysML4Modelica profile
 - a Modelica abstract syntax metamodel
 - a mapping between Modelica and the profile

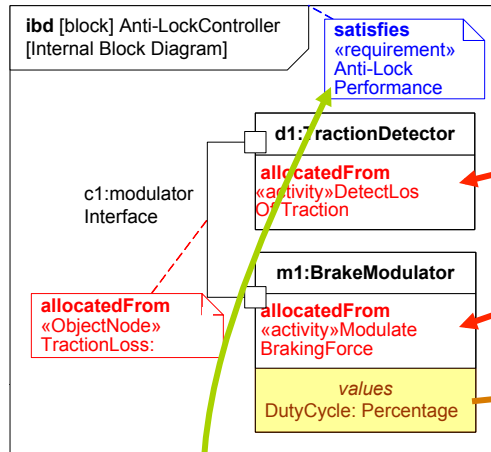
Presentation Overview



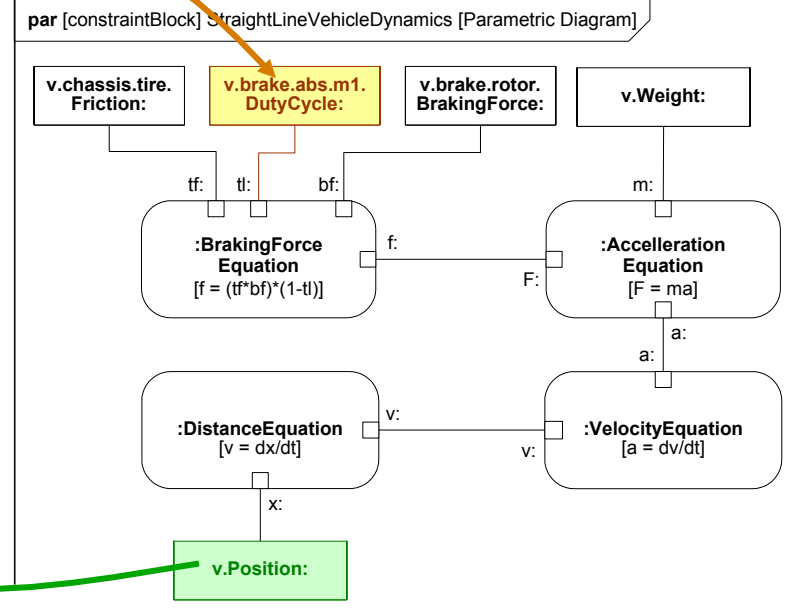
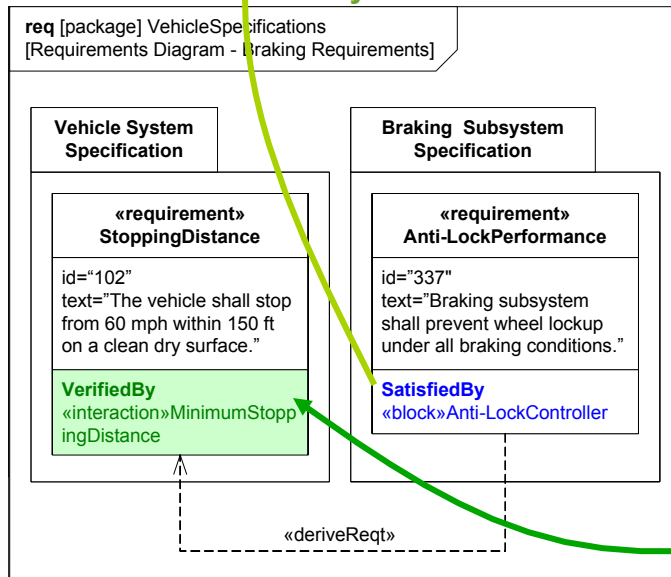
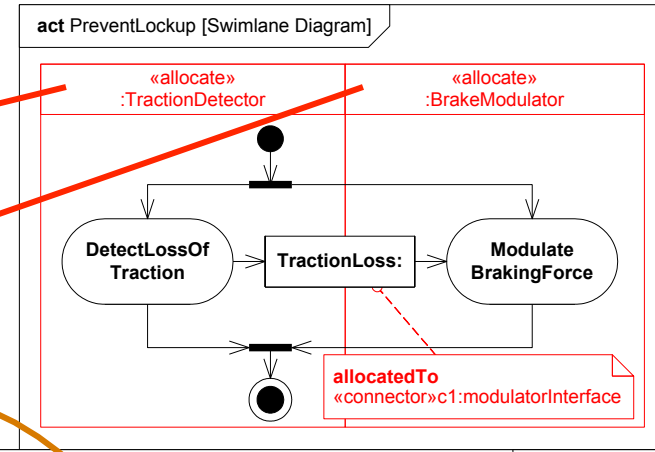
- What is SysML?
- What is Modelica?
- Motivating Example: Design & Analysis of Robot
- SysML-Modelica Transformation Specification
- Transformations in Systems Modeling
- Timeline towards Specification Adoption
- Summary

What is SysML? (www.omgsysml.org)

1. Structure



2. Behavior



4. Requirements

verify

3. Parametrics

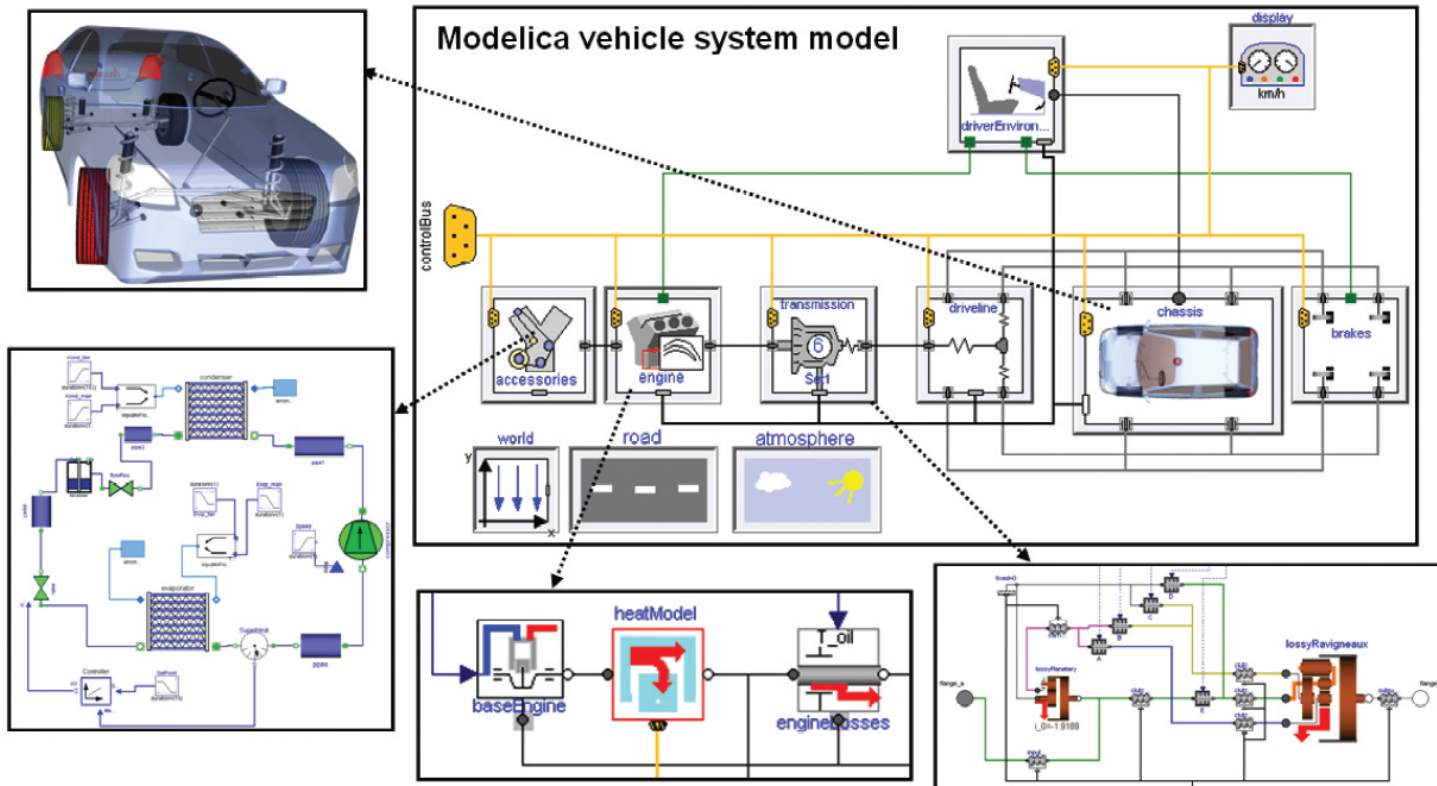
What is Modelica? (www.modelica.org)



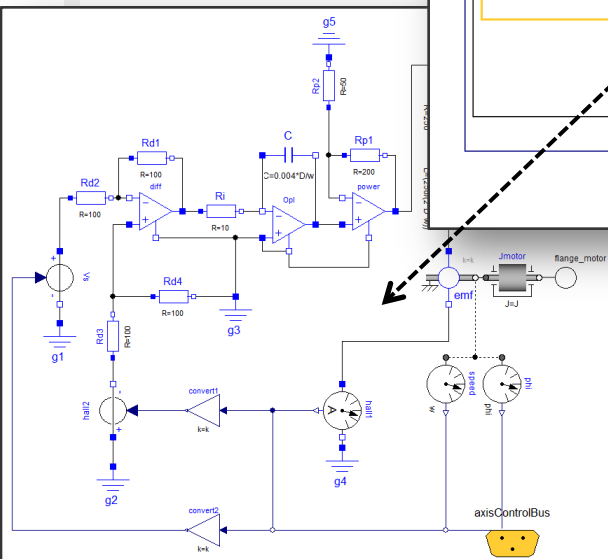
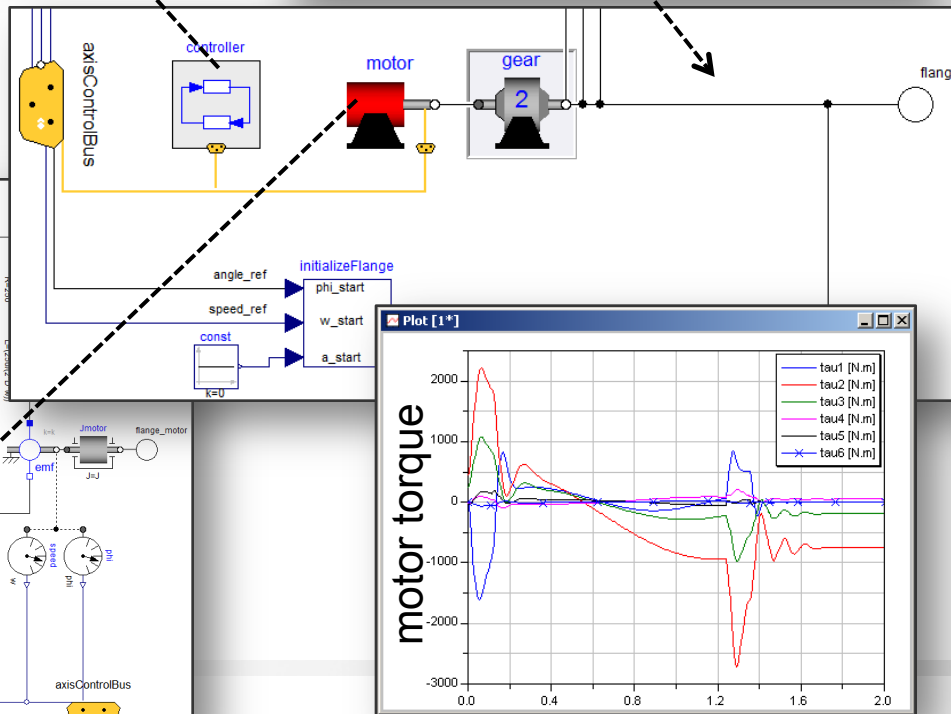
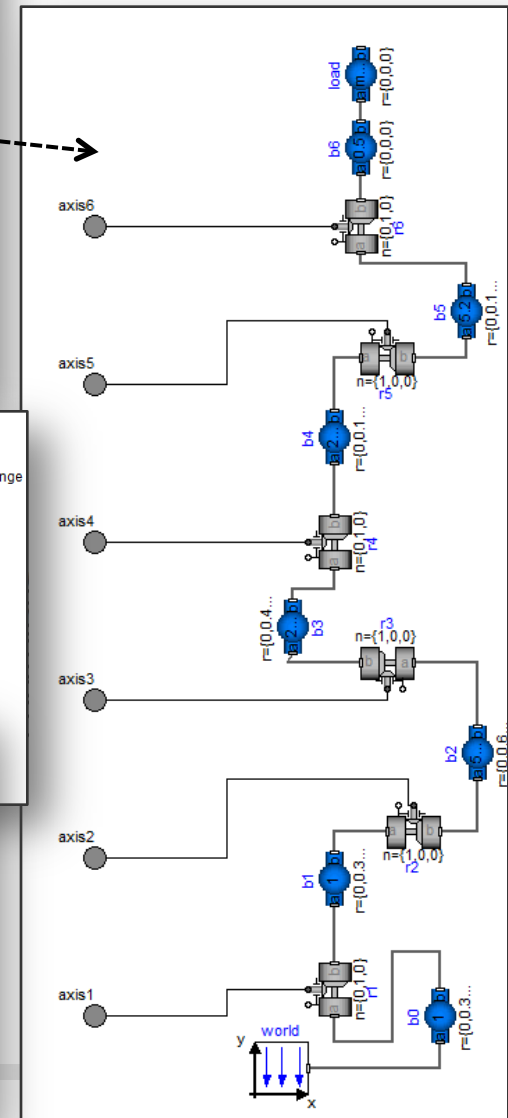
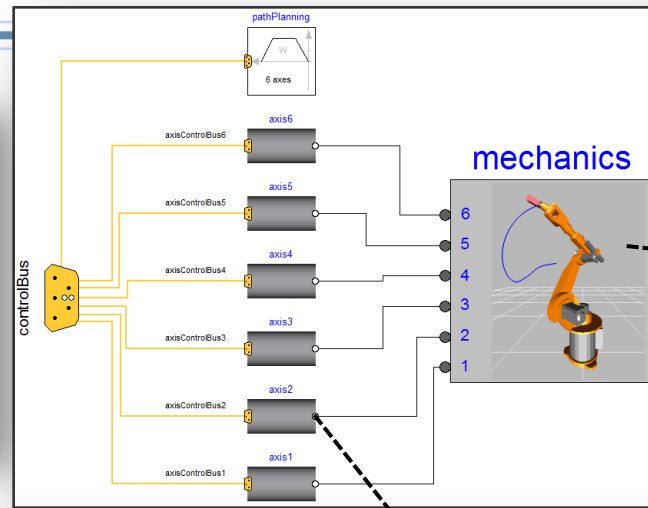
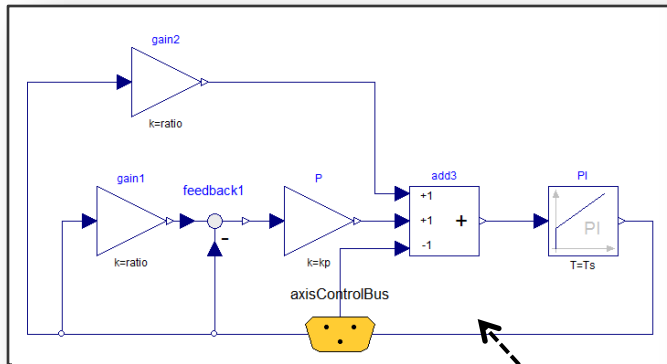
- State-of-the-art Modeling Language for System Dynamics
 - Differential Algebraic Equations (DAE)
 - Discrete Events
- Formal, object-oriented language
- Standardized by the Modelica Association
 - Open language specification – tool independent
- Multi-domain modeling
- Ports represent energy flow (undirected) or signal flow (directed)
- Acausal, equation-based, declarative ($f-m \cdot a=0$)

Modelica: Active and Mature Community

- Modelica association — 20+ free libs (www.modelica.org)
- 6 commercial solvers, 3 open-source solvers (Dymola, MapleSim, SimulationX, OpenModelica,...)
- EUROSYSLIB project — 20+ libs under development (http://www.itea2.org/public/project_leaflets/EUROSYSLIB_profile_oct-07.pdf)

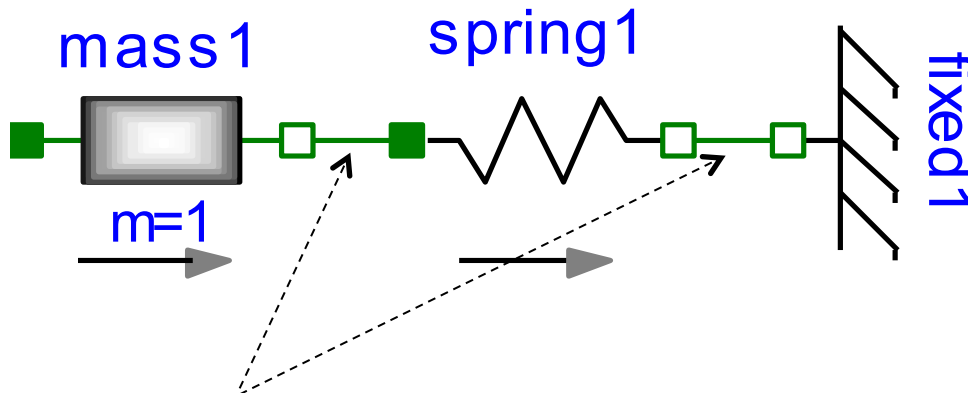


A Robot Example in Modelica



Modelica Semantics and Textual Syntax

```
model Spring "Linear 1D translational spring"
  extends Translational.Interfaces.PartialCompliant;
  parameter SI.TranslationalSpringConstant c(final min=0, start = 1)
    "spring constant ";
  parameter SI.Distance _rel0=0 "unstretched spring length";
equation
  f = c*(s_rel - s_rel0);
end Spring;
```



Graphical symbols
defined as
annotations in
textual models

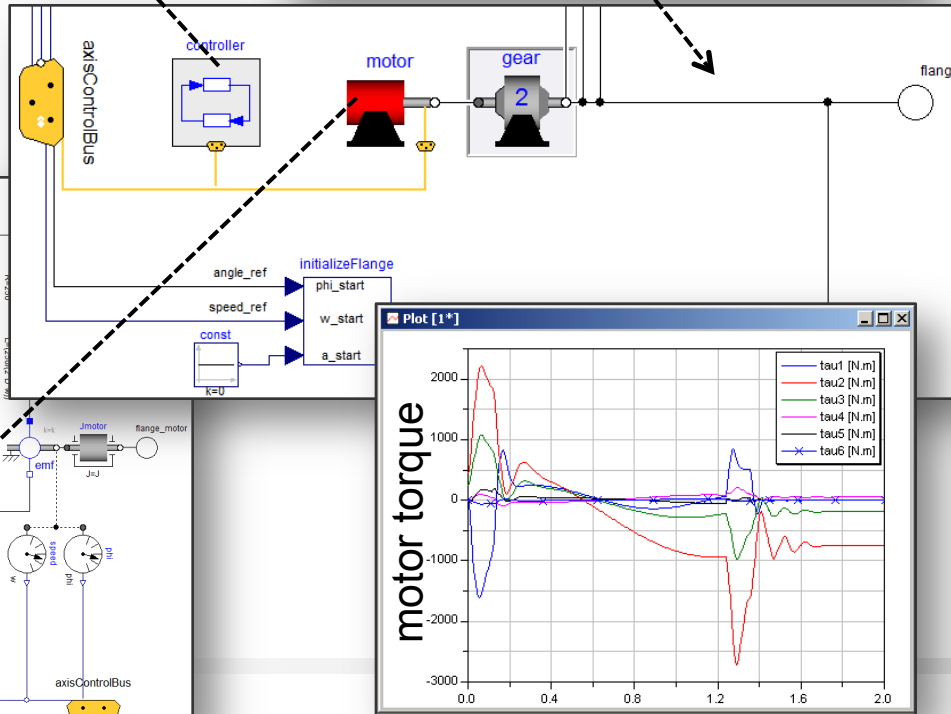
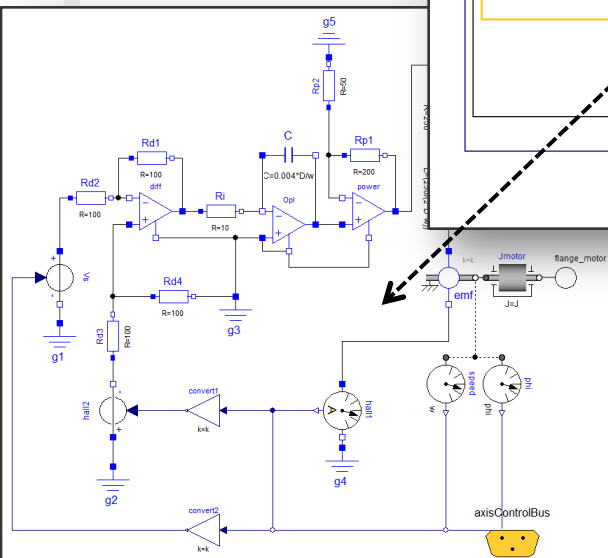
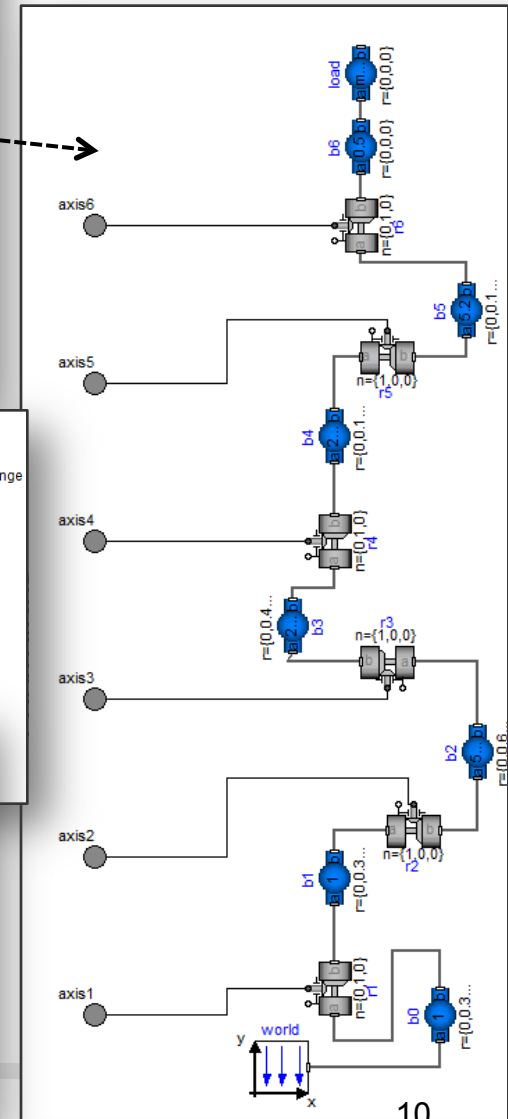
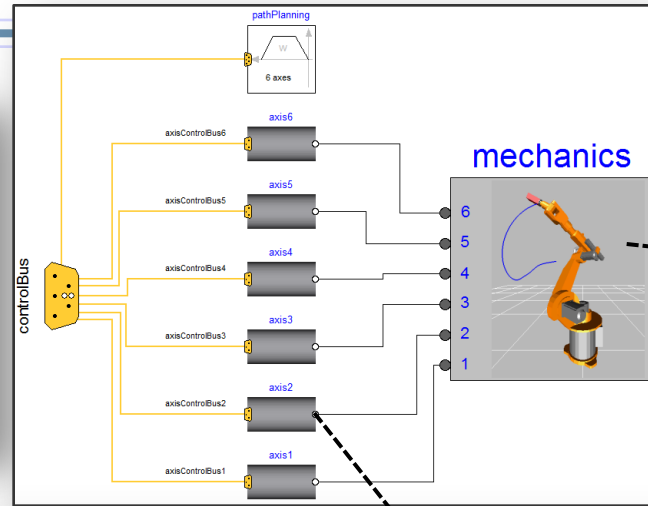
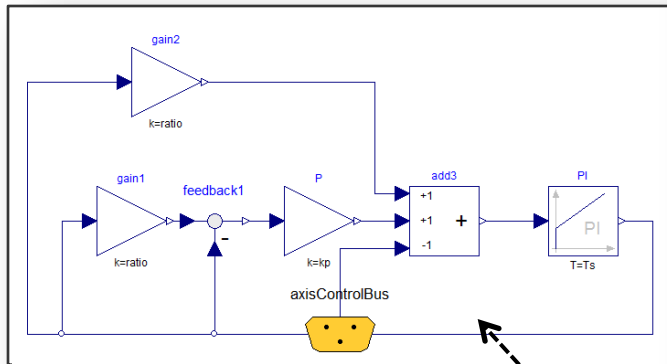
- Connections represent Kirchhoff semantics
 - Across variables (voltage, pressure,...) are equal
 - Through variables (current, flow rate,...) add to zero

- What is SysML?
- What is Modelica?

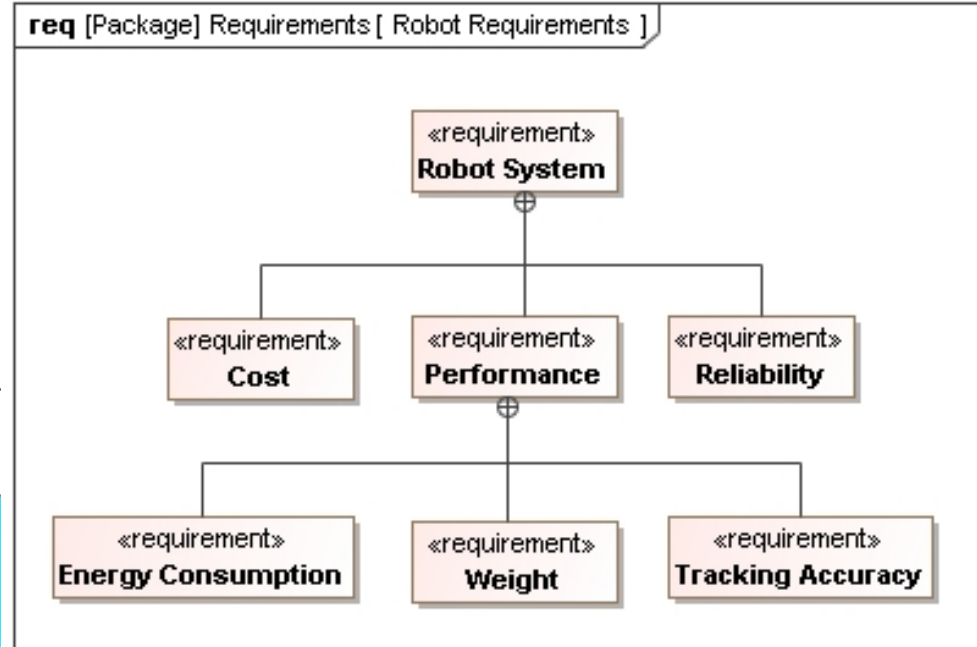
Motivating Example: Design & Analysis of Robot

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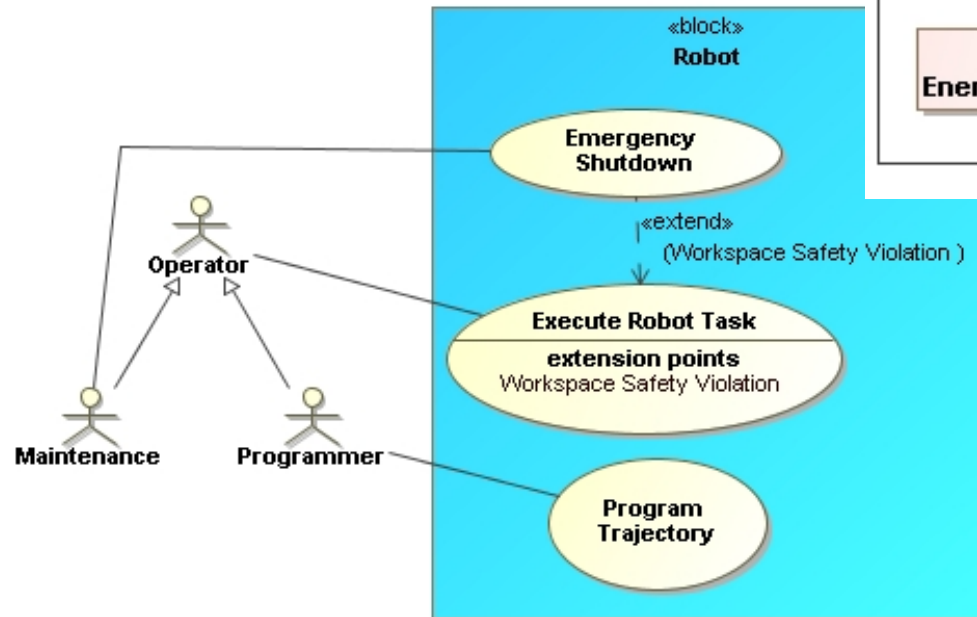
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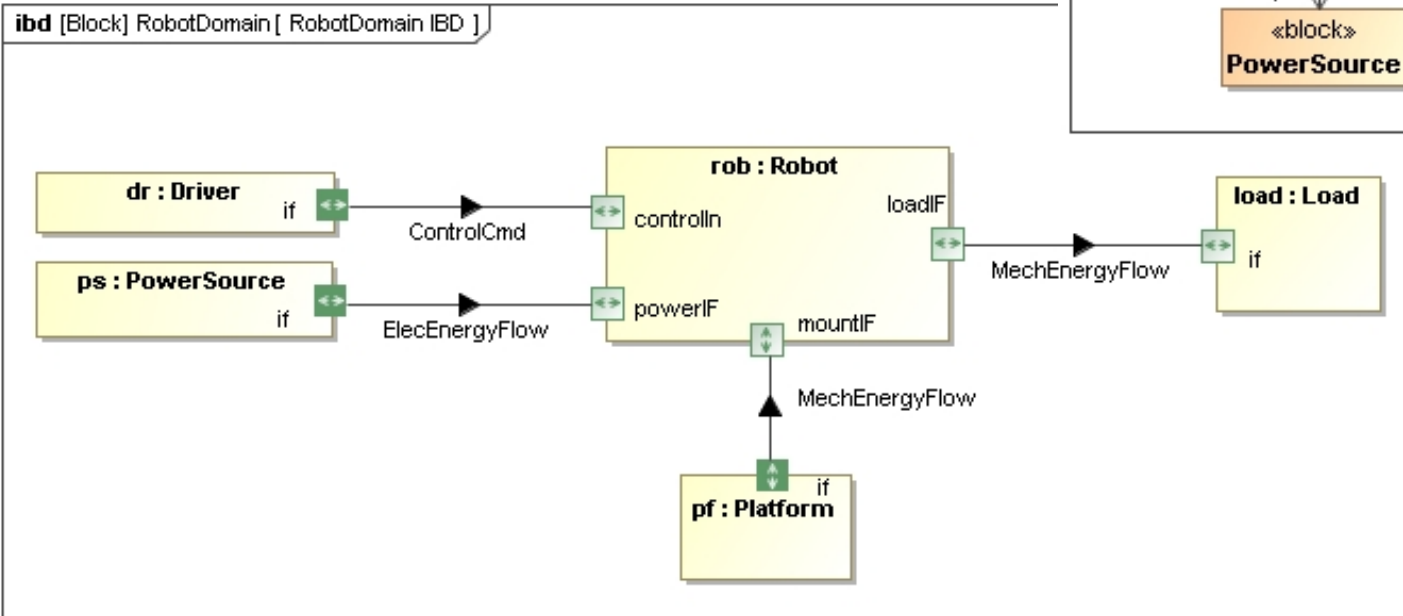
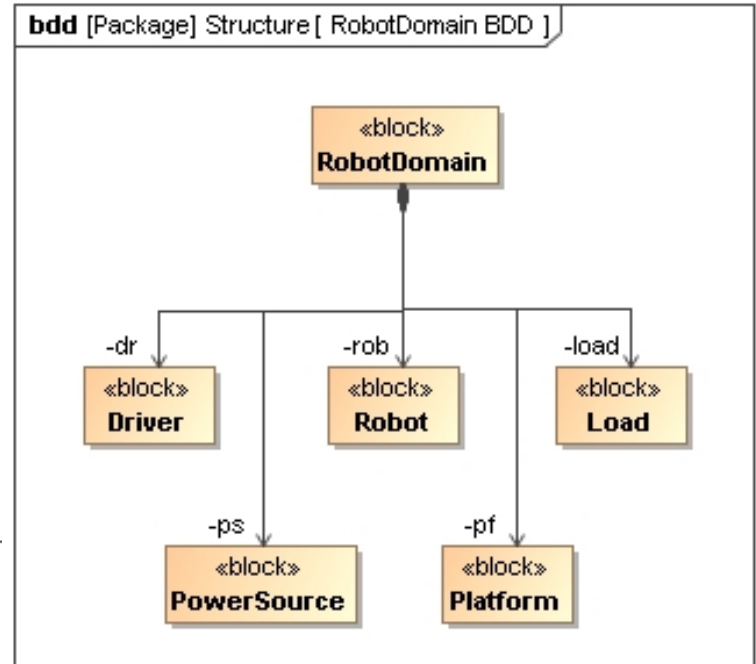
SysML-Modelica Robot Example: UseCases & Requirements

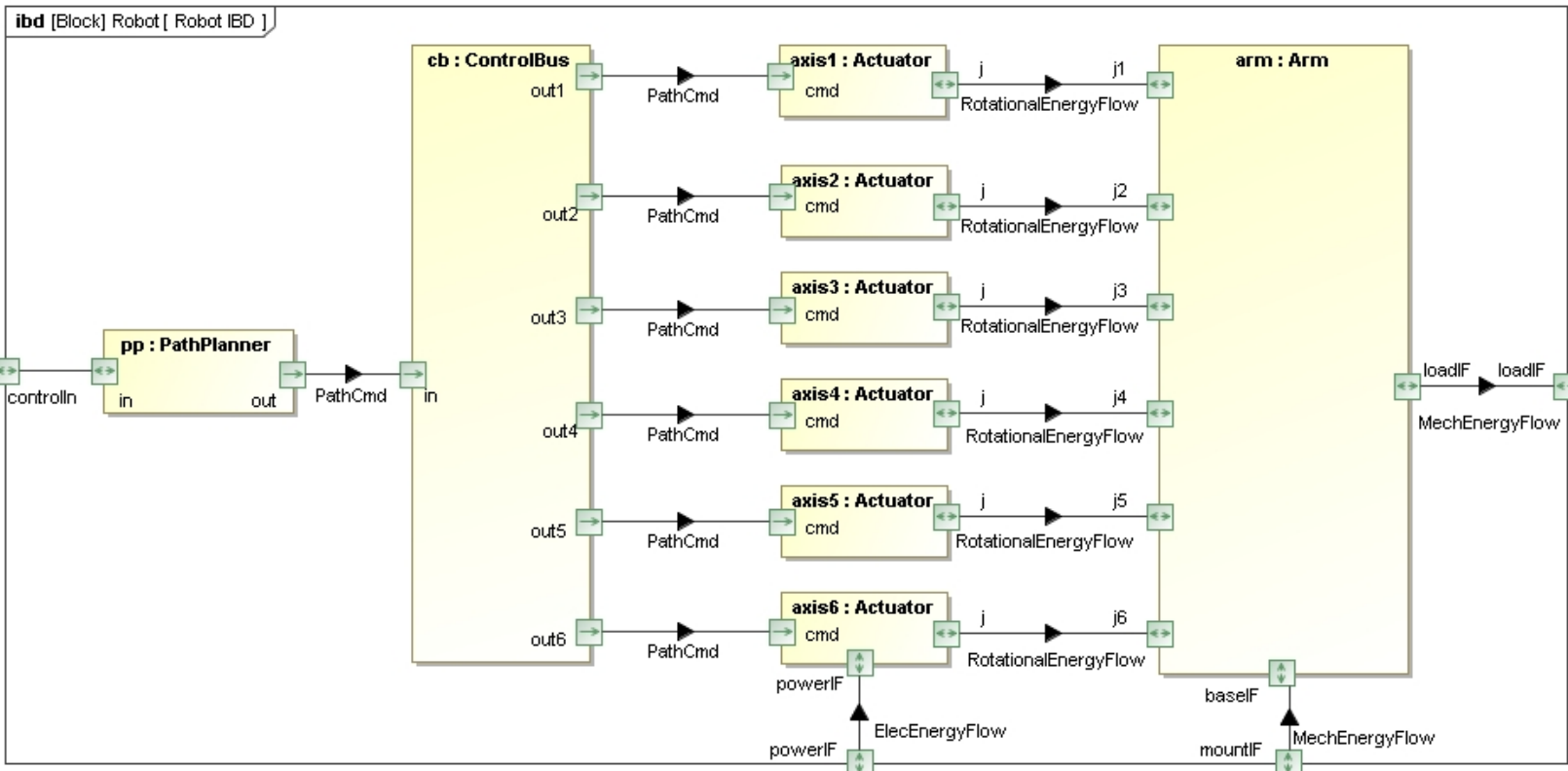


uc [Package] Behavior [Main Robot Use Cases]

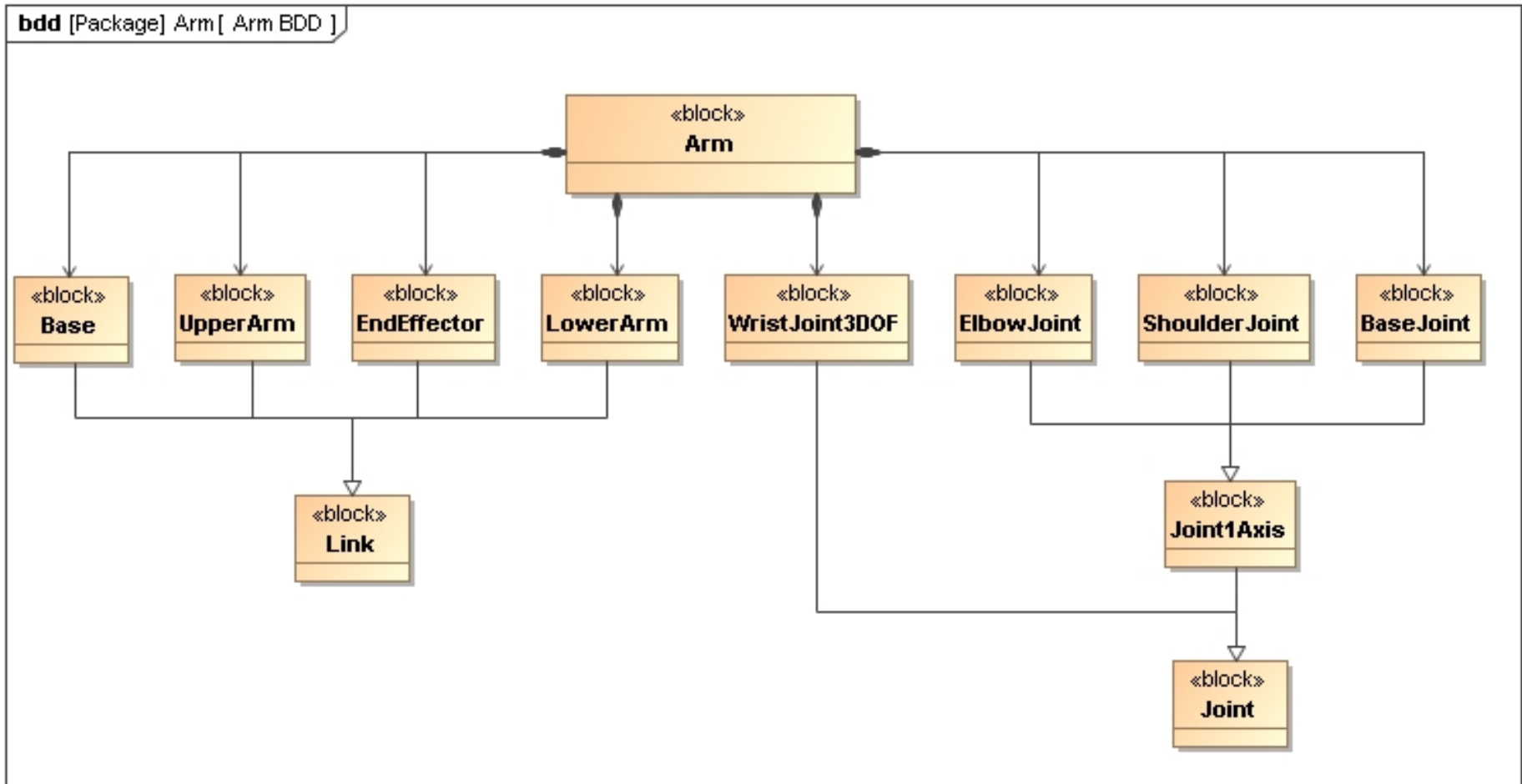


SysML-Modelica Robot Example: Robot Domain BDD & IBD

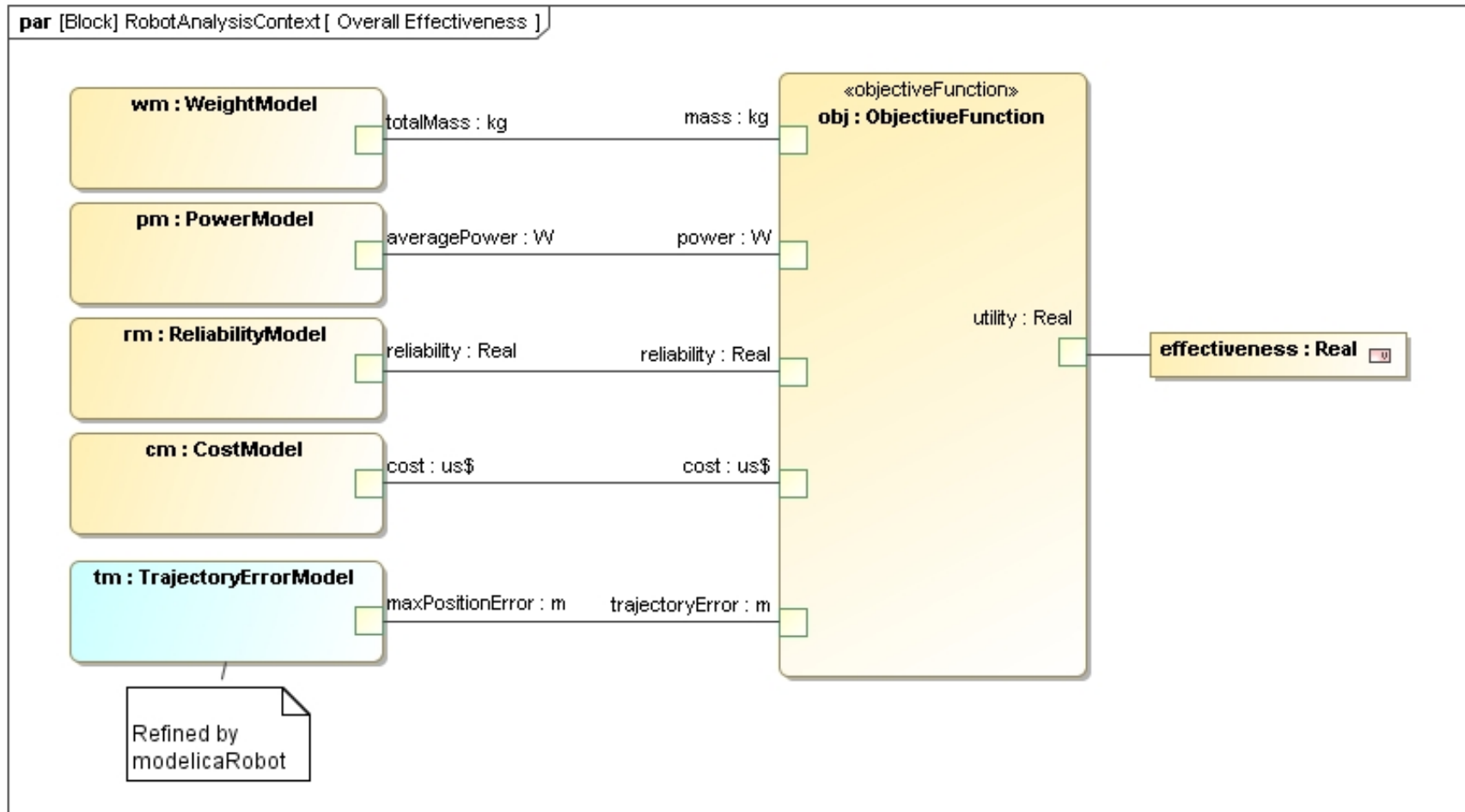




SysML-Modelica Robot Example: Robot Arm BDD

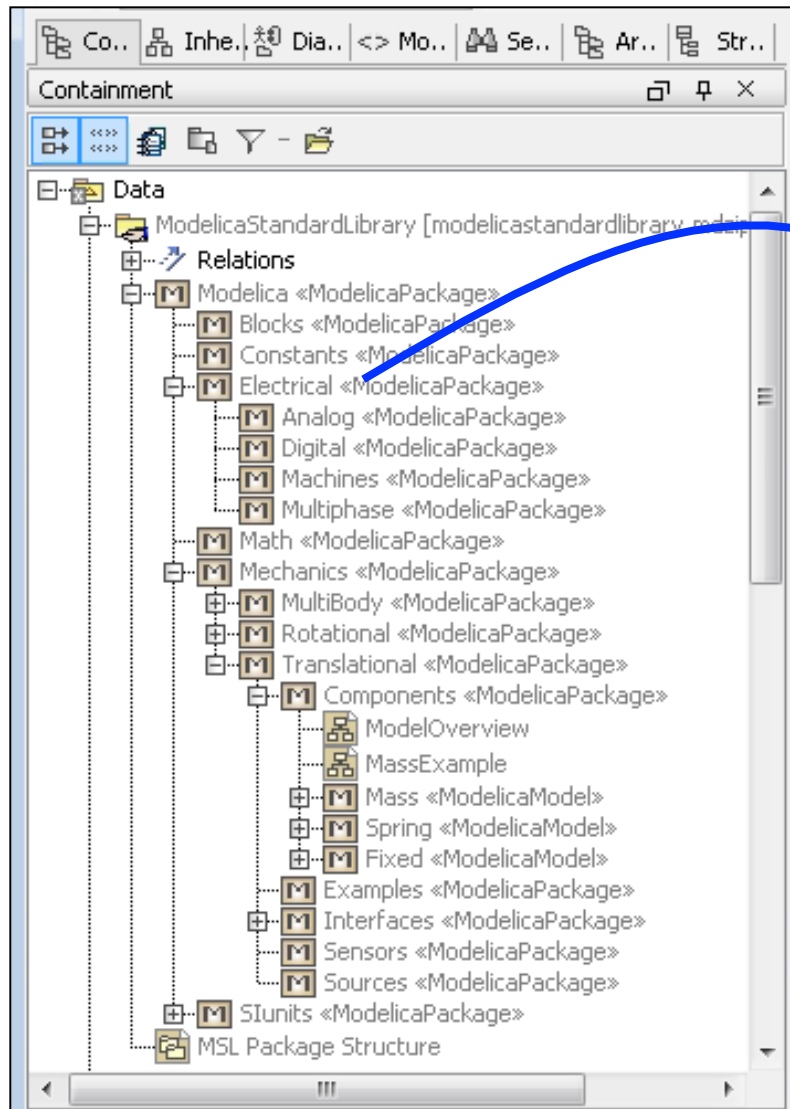


SysML-Modelica Robot Example: Analysis and Trade Study

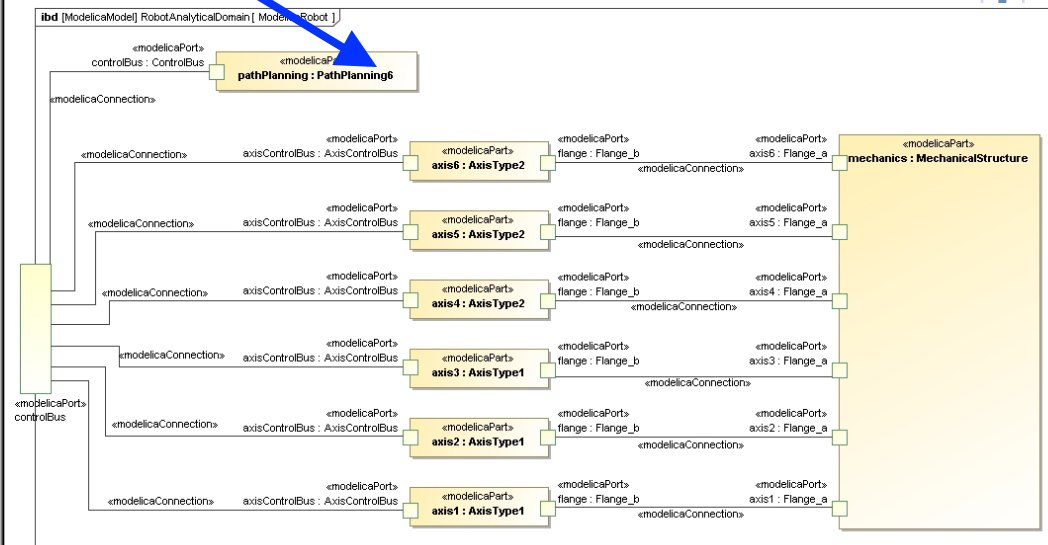


Analysis models depend on descriptive models

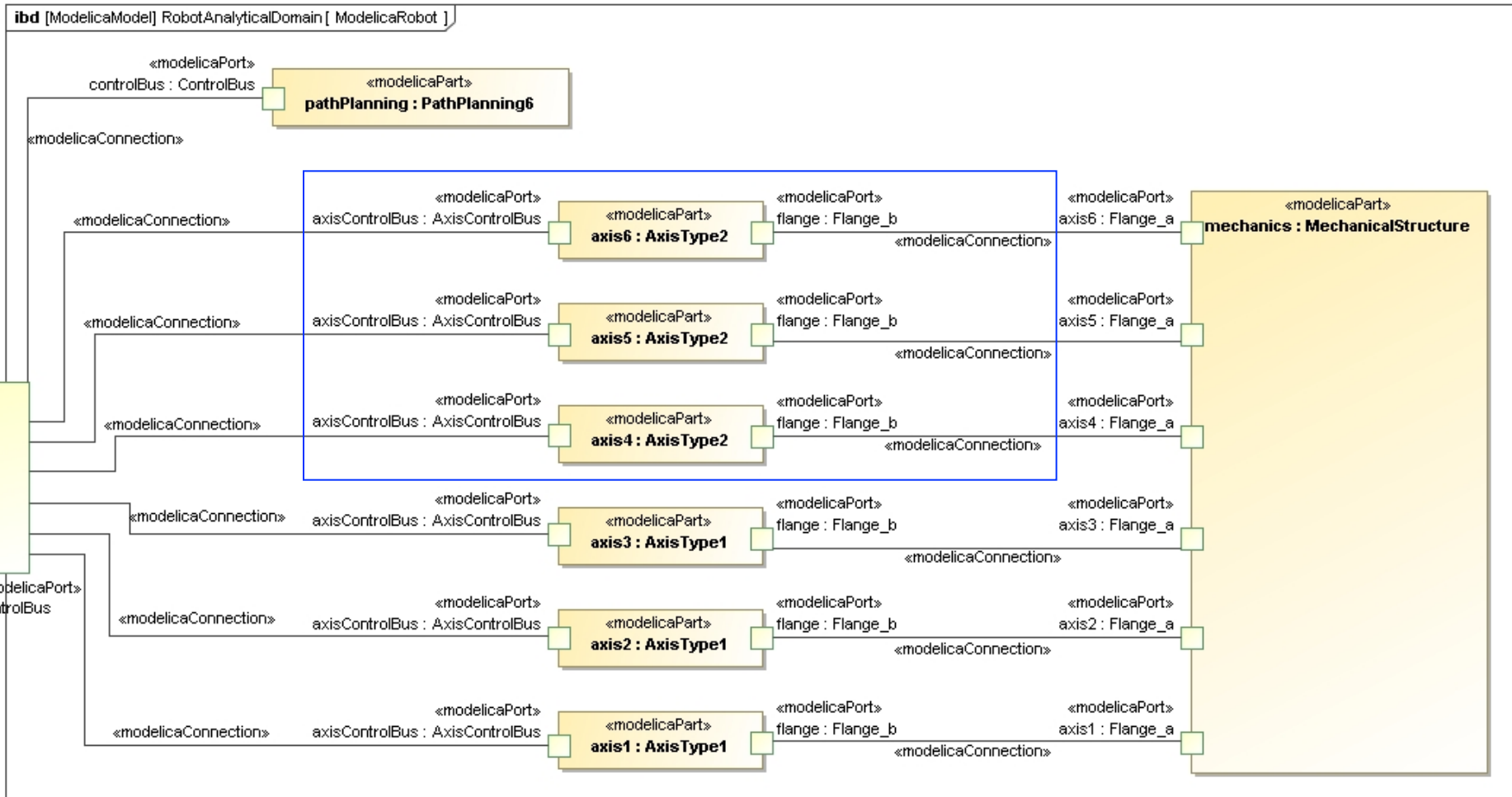
SysML4Modelica Analytical Model: Compose Model from SysML Standard Library



Drag and drop into
IBD [ModelicaModel]

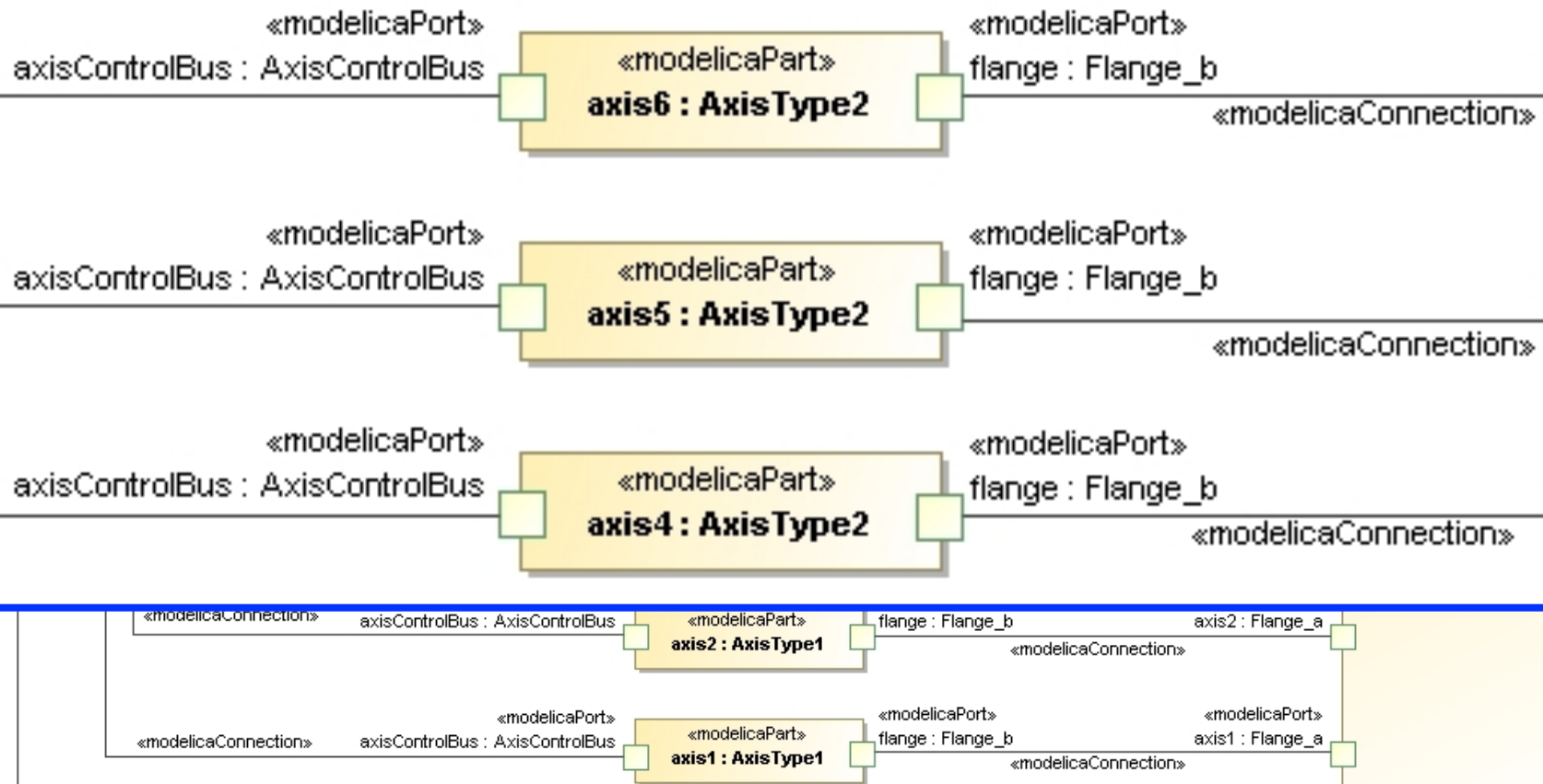


SysML4Modelica Analytical Model: Detailed IBD

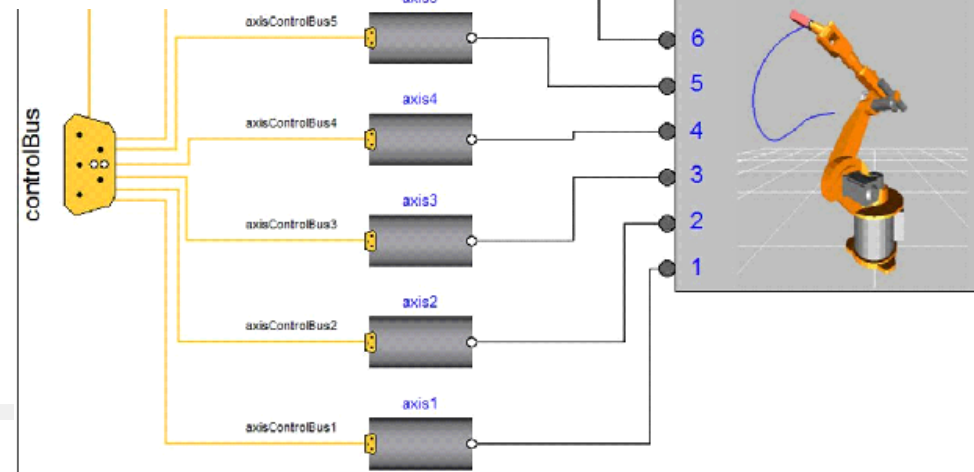
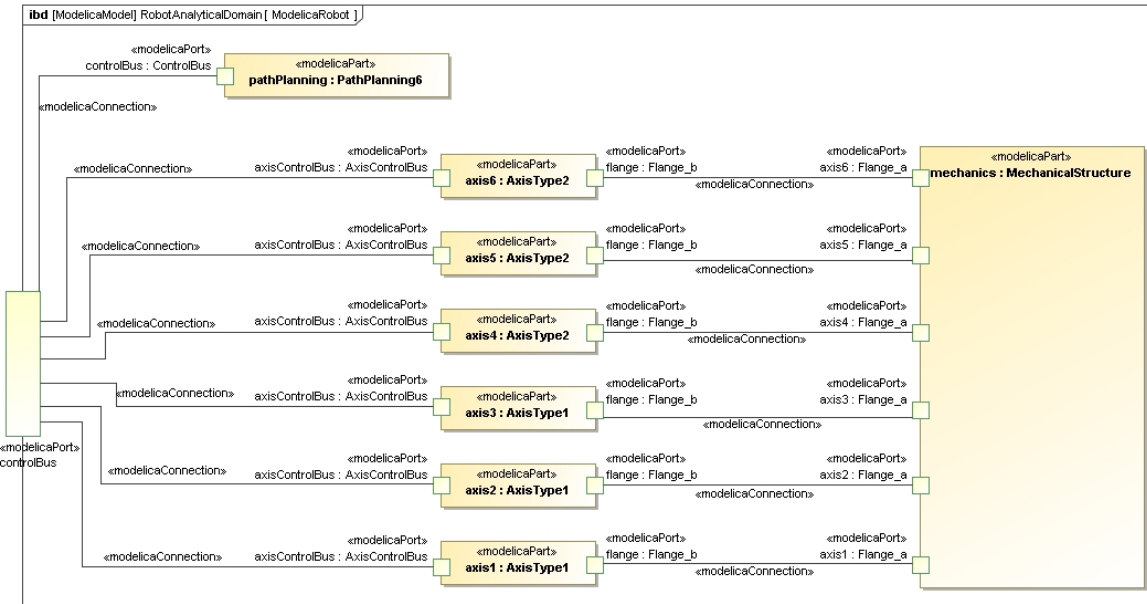


SysML4Modelica Analytical Model: Detailed IBD

ibd [ModelicaModel] RobotAnalyticalDomain [ModelicaRobot]

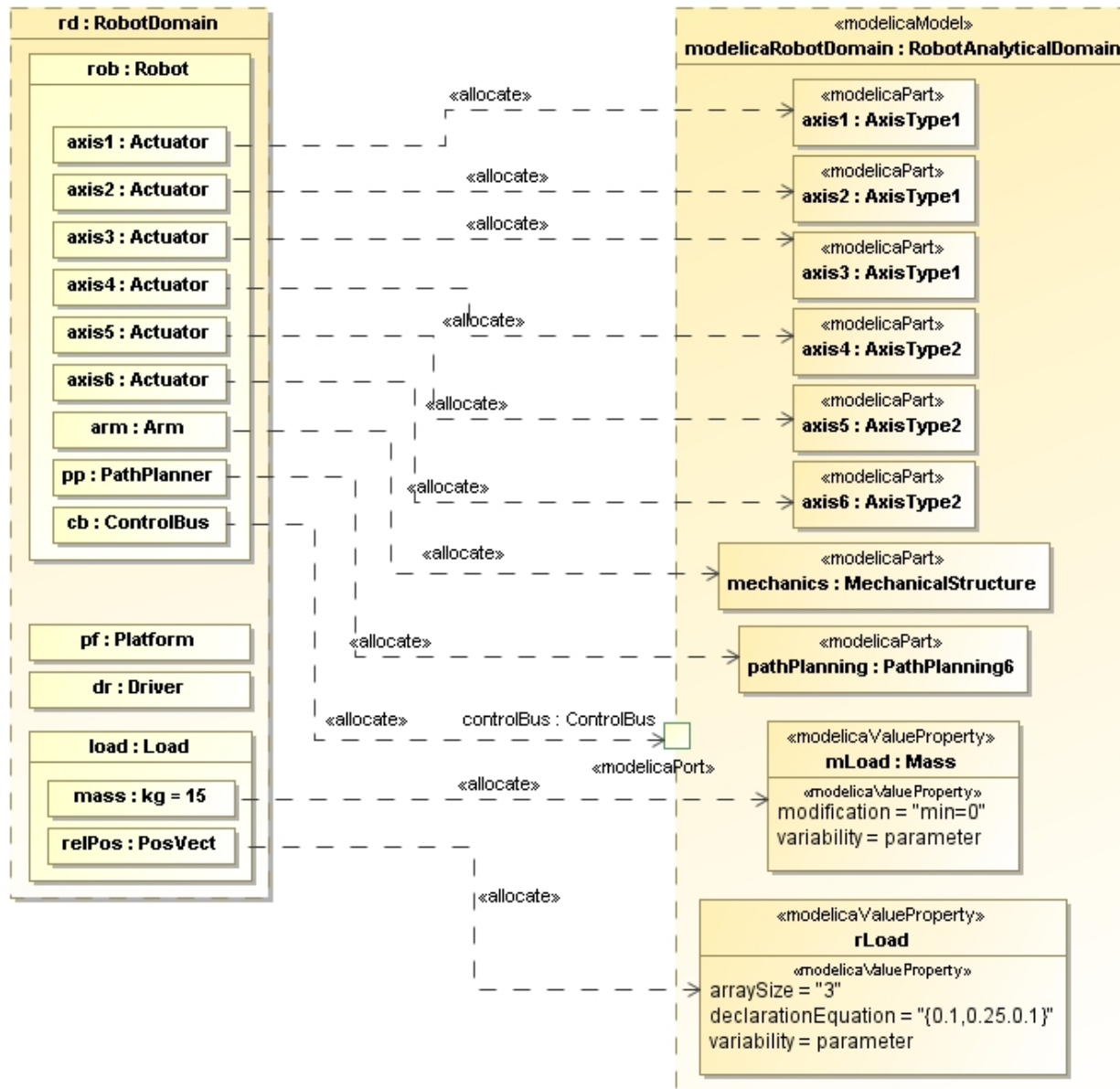


SysML4Modelica Analytical Model: Relation to Modelica Native Model

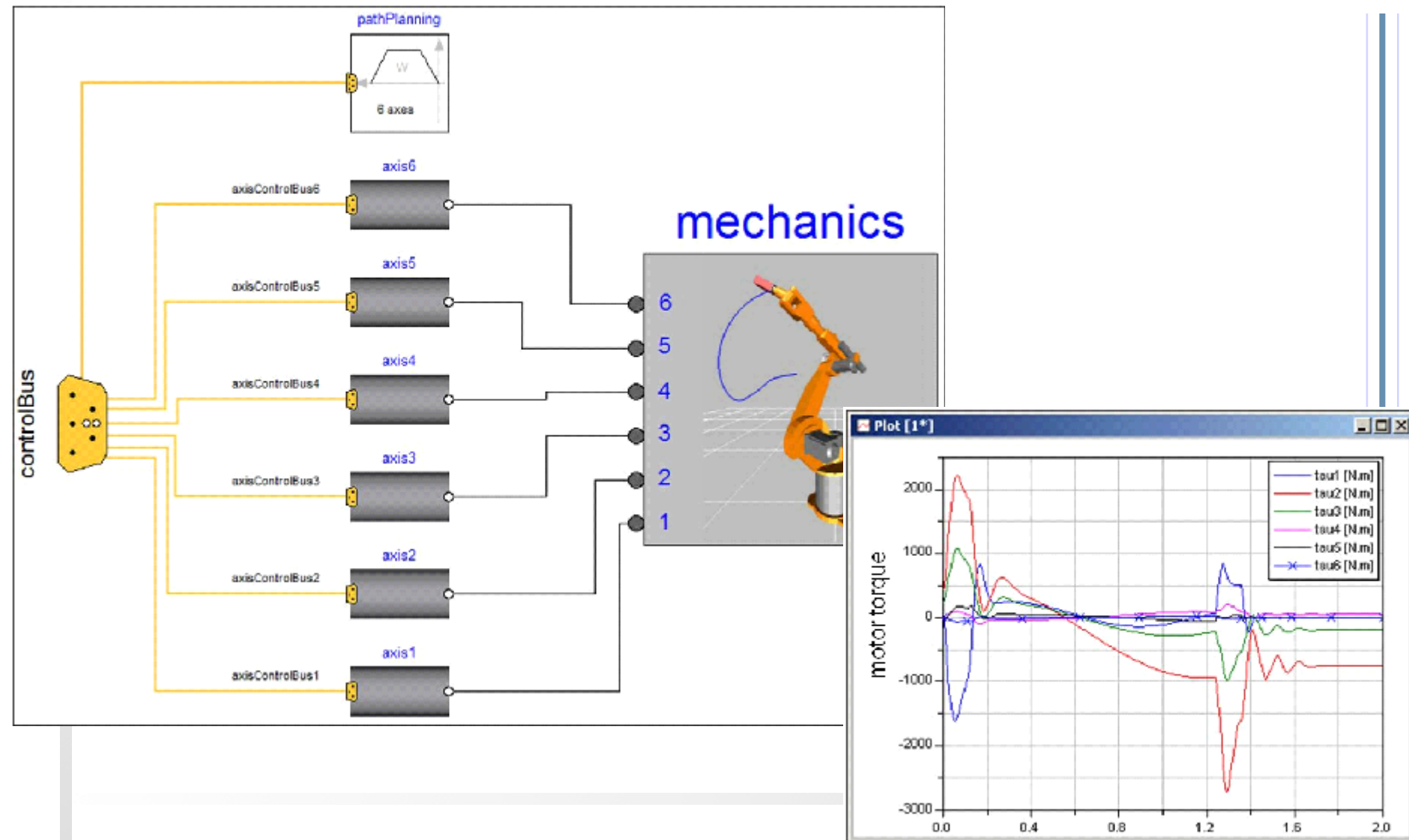


SysML4Modelica Analytical Model: Allocation

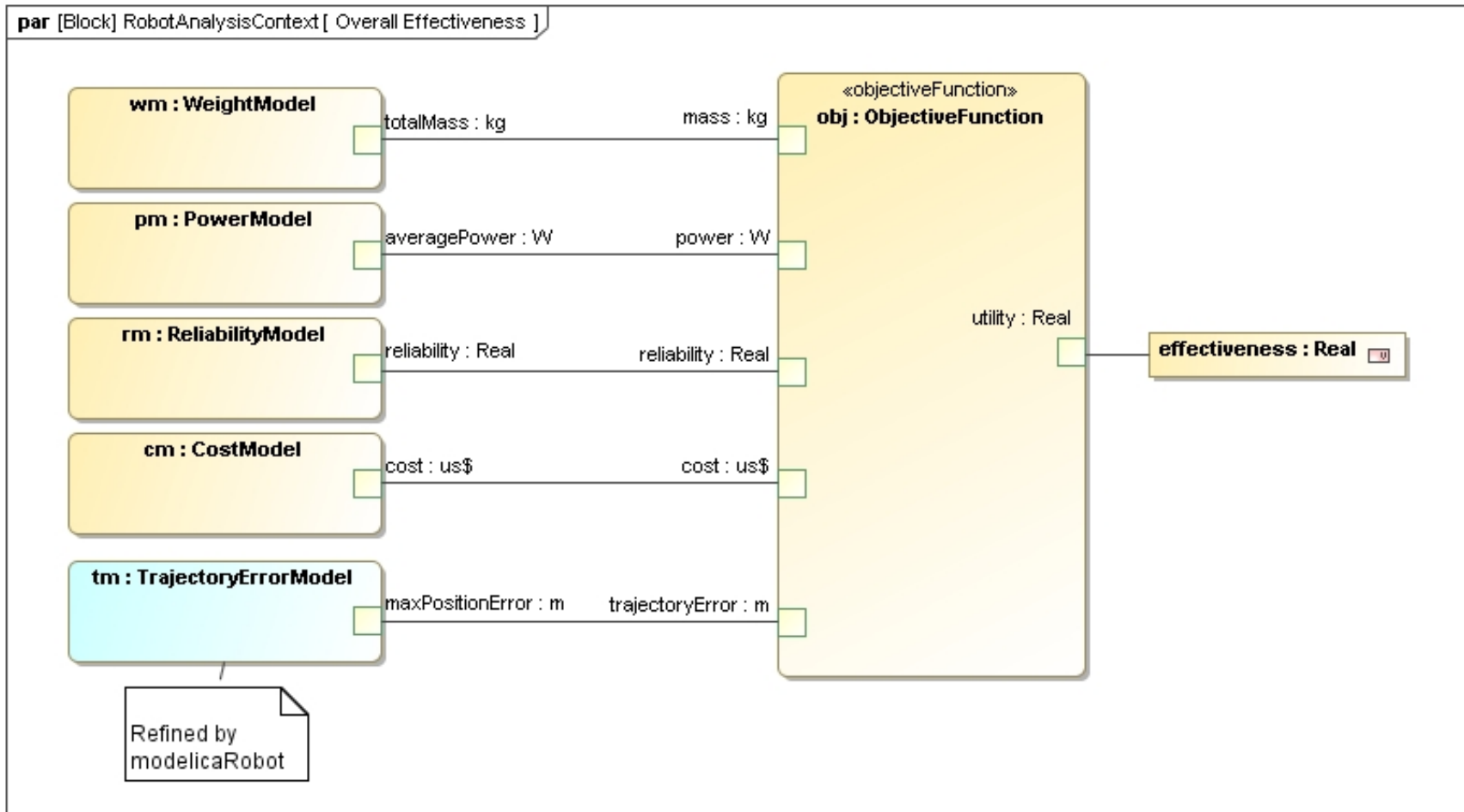
ibb [Block] RobotAnalysisContext [Structural Model to Analytical Model Correspondence]



SysML-Modelica Robot Example: Modelica model with simulation results



SysML-Modelica Robot Example: Analysis and Trade Study



Analysis results are incorporated in Trade Study

Presentation Overview

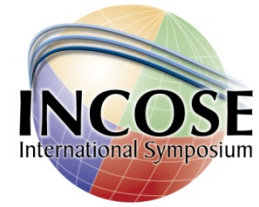


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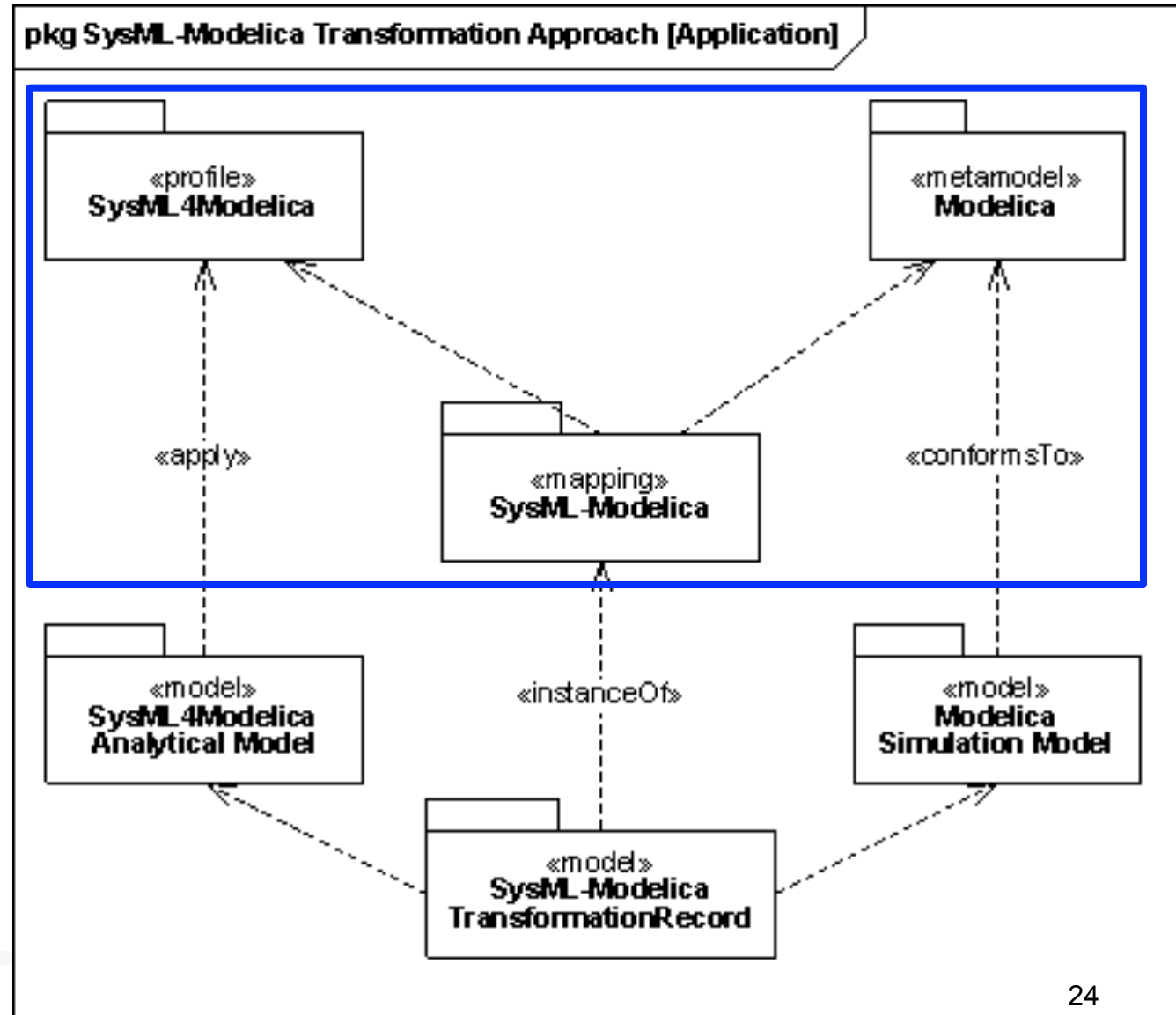
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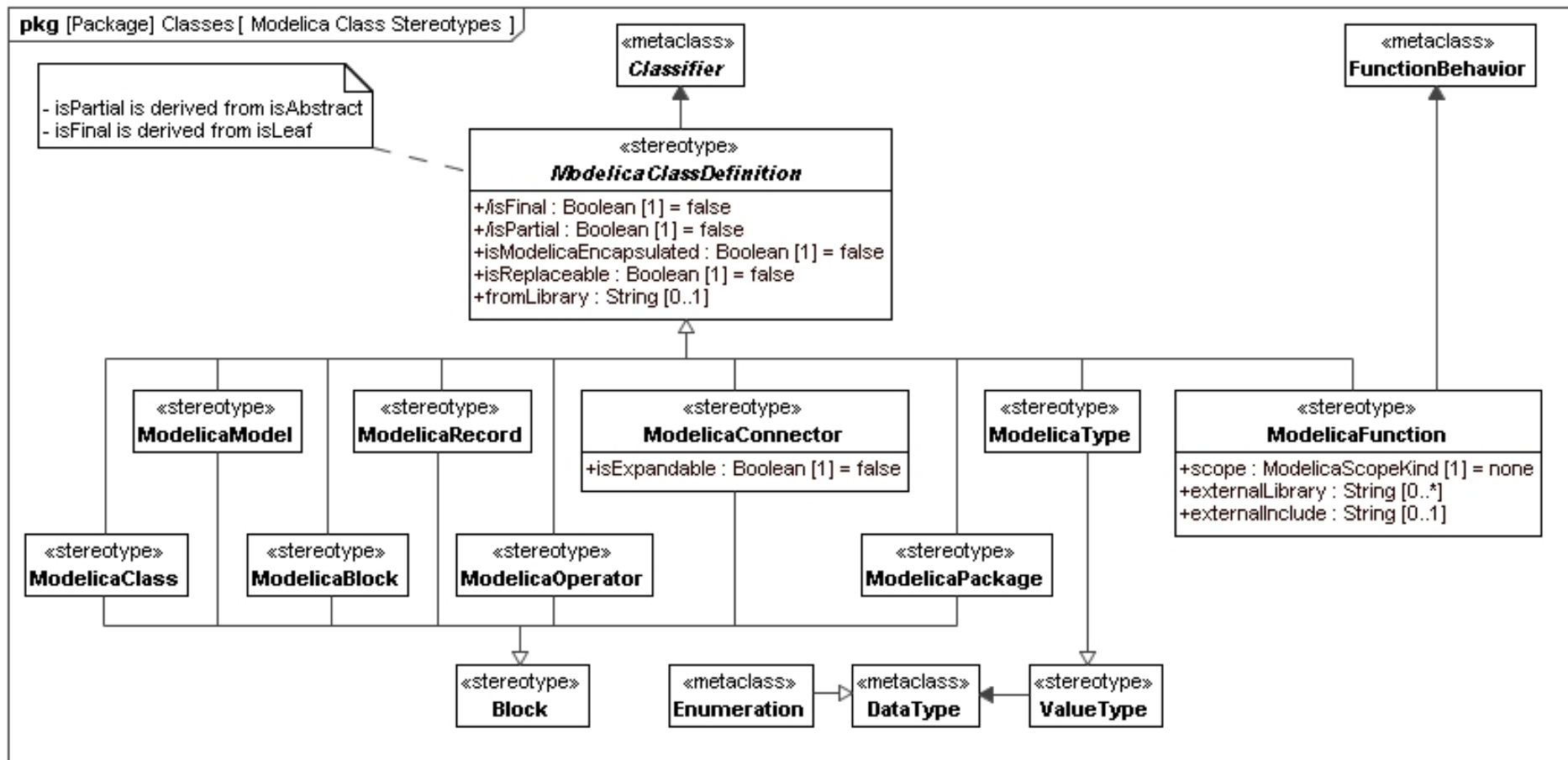
SysML-Modelica Transformation Specification



SysML-
Modelica
Transformation
follows the
principles
of Model-
Driven
Architecture
(MDA)

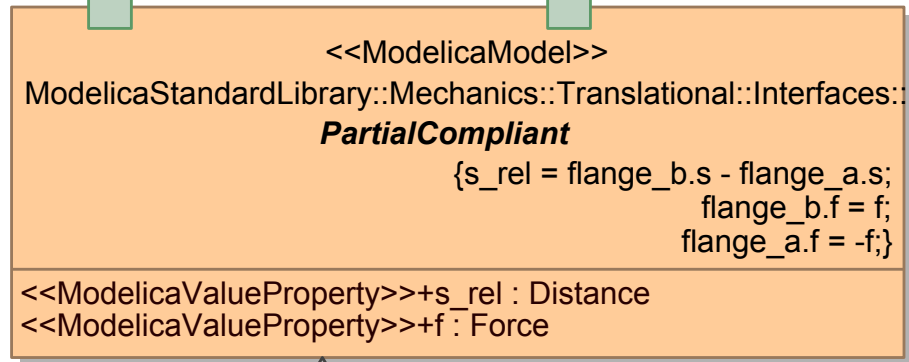


SysML4Modelica Profile



<<ModelicaPort>>
flange_a : Flange

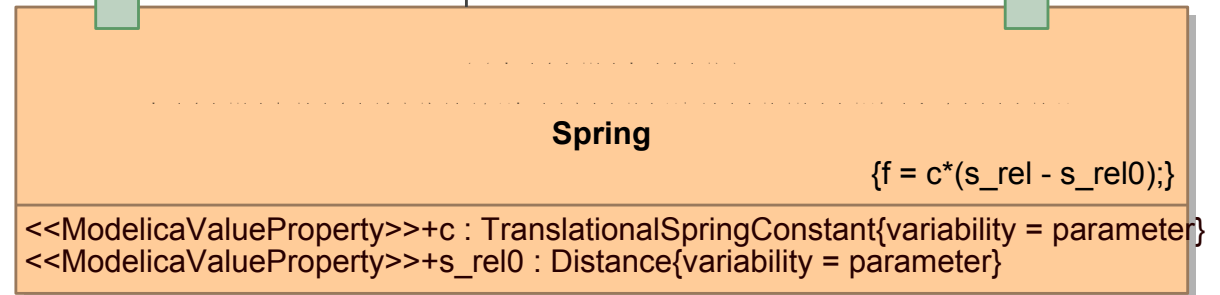
<<ModelicaPort>>
flange_b : Flange



<<ModelicaPort>>
flange_a : Flange

<<ModelicaExtendsRelation>>

<<ModelicaPort>>
flange_b : Flange



```

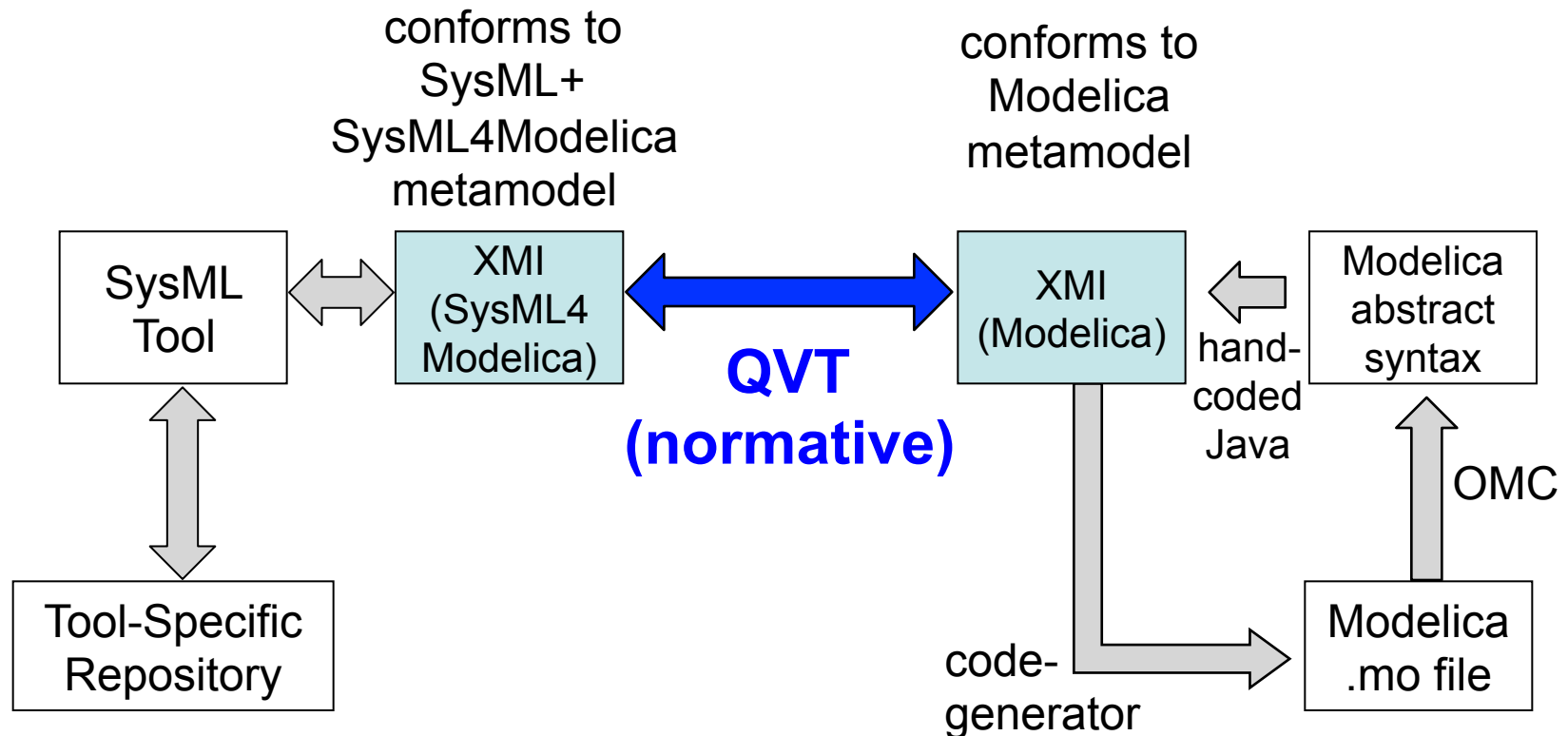
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equation
  f = c*(s_rel - s_rel0);
end Spring;
  
```

SysML4Modelica

Formal
mapping

Modelica

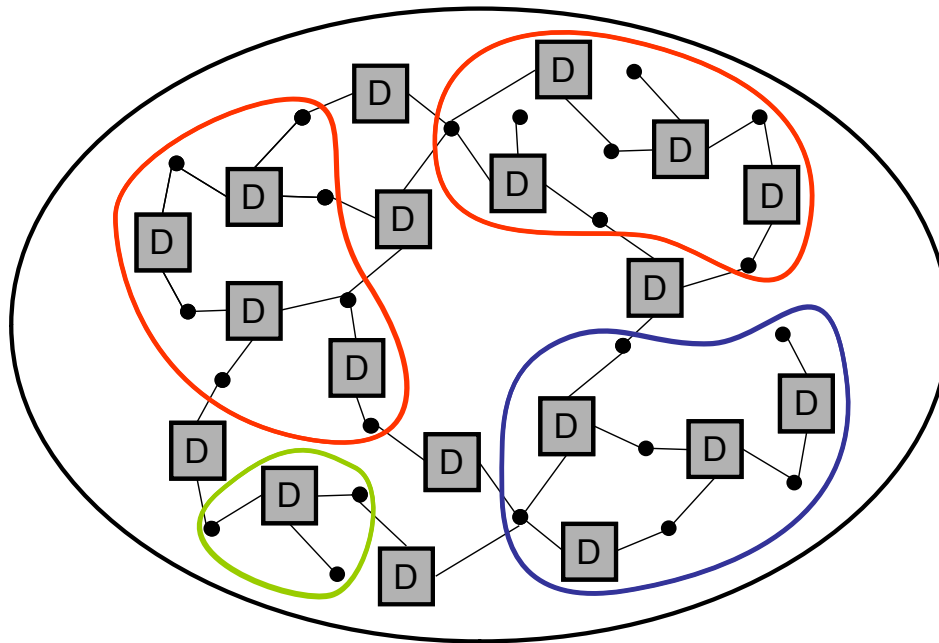
Reference implementation: Based on OMG QVT



QVT = Query / View / Transformation

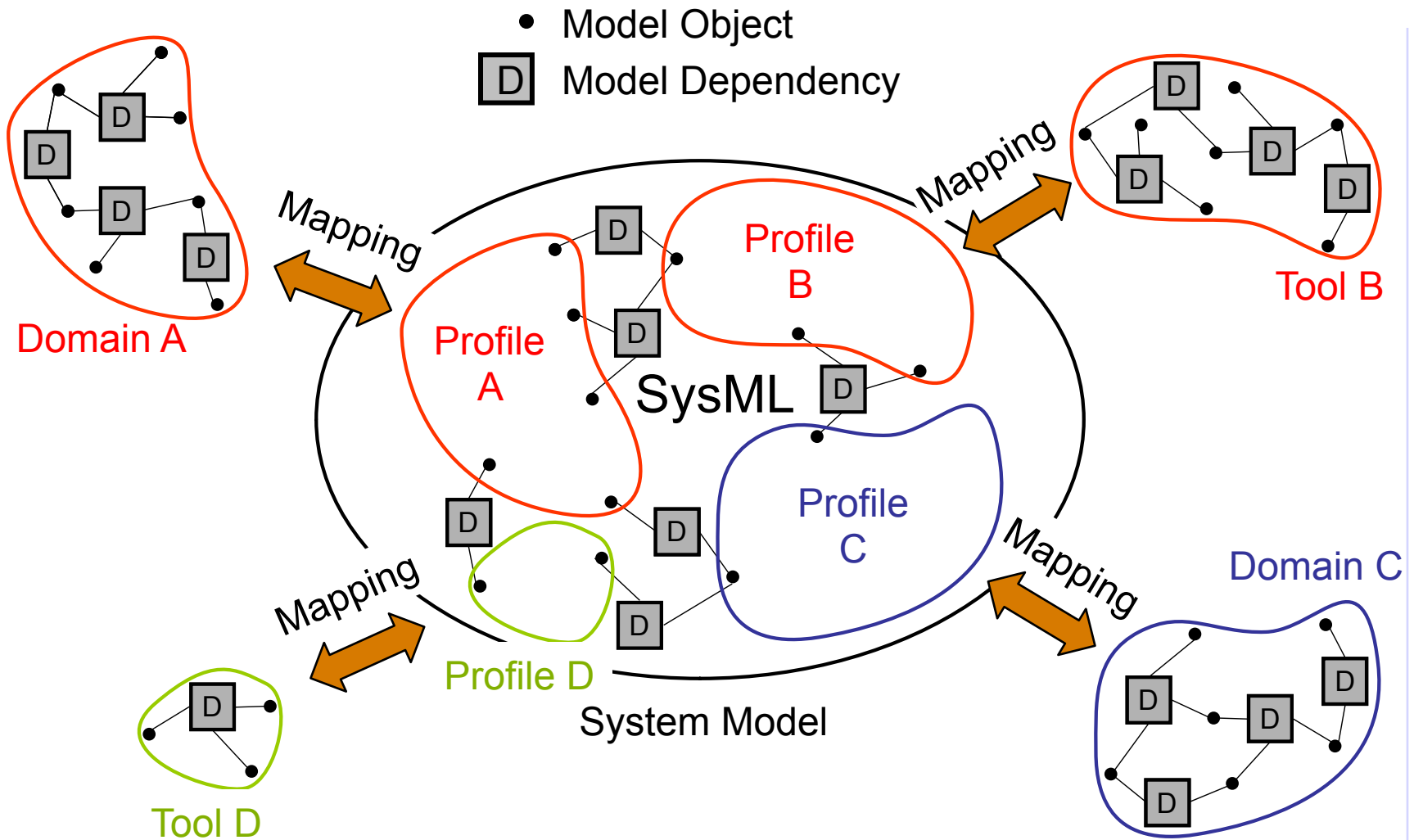
Transformations in Systems Modeling

- Model Object
- D Model Dependency

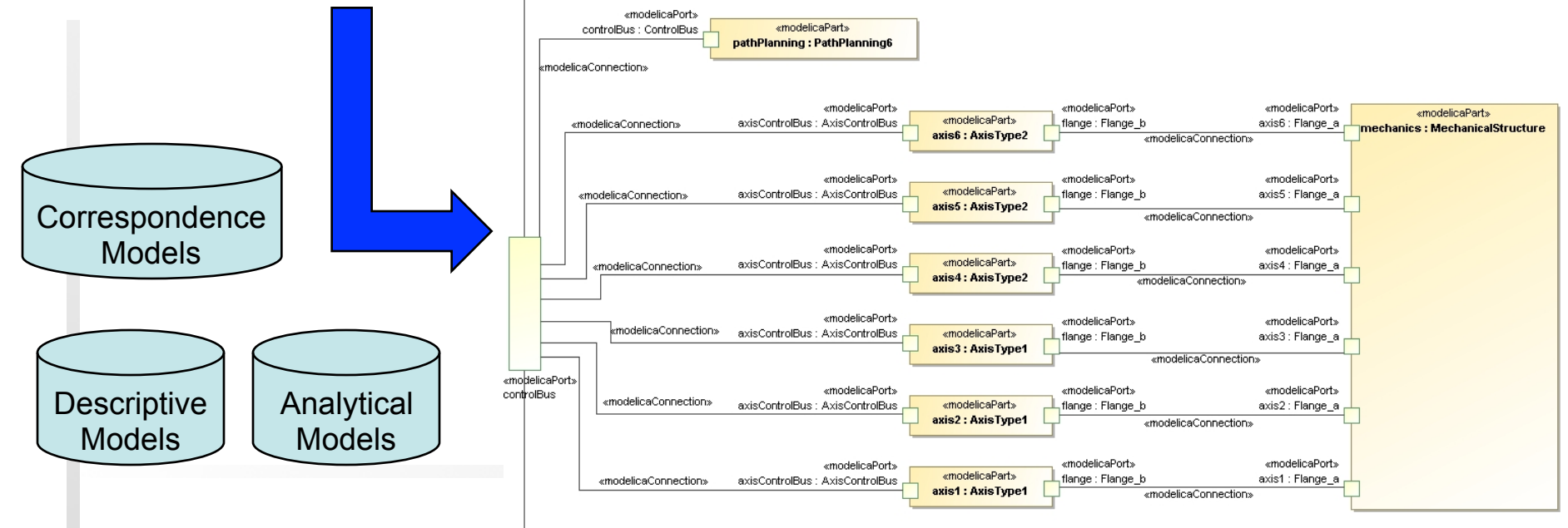
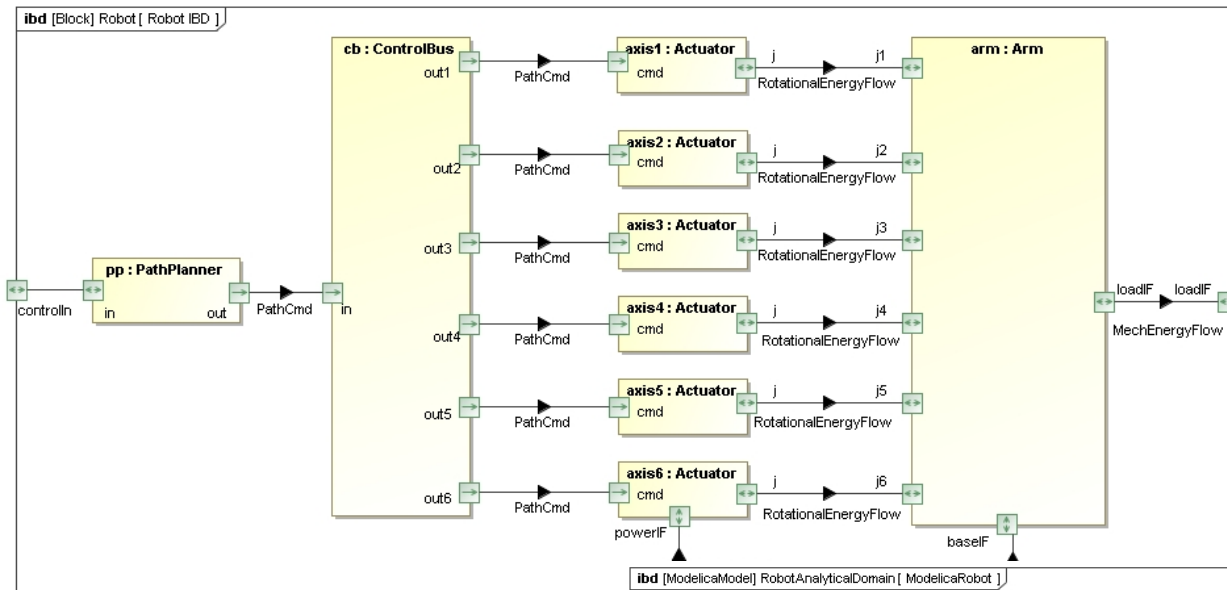


System Model

Transformations in Systems Modeling



Descriptive to Analytical Transformation



Correspondence
Models

Descriptive
Models

Analytical
Models

Timeline of Specification Adoption



➤ SysML

- SysML RFP: March 2003
- 1.0 Specification: September 2007
- Currently: Revision Task Force 1.3

➤ Modelica

- 1.0 Specification: September 1997
- 3.1 Specification: May 2009

➤ SysML-Modelica

- Initial idea: July 2005
- INCOSE MBSE Challenge Project: August 2007 – now
- OMG Working Group established: December 2008
- Approved for public comment (RFC): June 2010
- Future: Adoption as OMG Specification in September 2010 (?)

➤ Objective:

- Leverage the strengths of both SysML and Modelica by integrating them to create a more expressive and formal MBSE language.

Descriptive Modeling in SysML + Formal Equation-Based Modeling for Analyses and Trade Studies in Modelica

<http://doc.omg.org/syseng/2010-6-8>

Acknowledgements: Working Group Members



- Yves Bernard (EADS)
- Roger Burkhart (Deere & Co)
- Wuzhu Chen (Univ. Braunschweig)
- Hans-Peter De Koning (ESA)
- Sandy Friedenthal (Lockheed Martin)
- Peter Fritzson (Linköping University)
- Nerijus Jankevicius (No Magic)
- Alek Kerzhner (Georgia Tech)
- Andreas Korff (Atego)
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