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

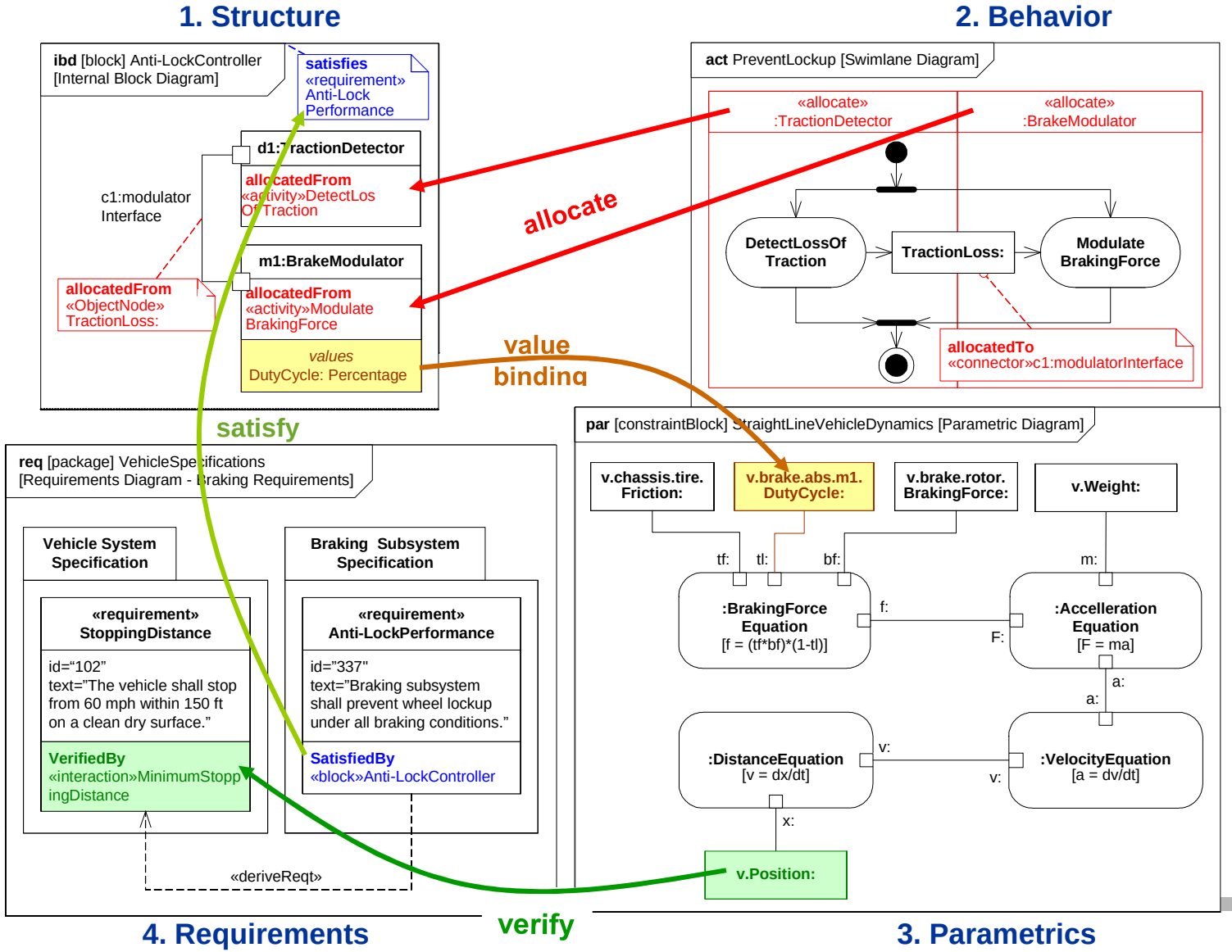
Presentation Overview

- 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)

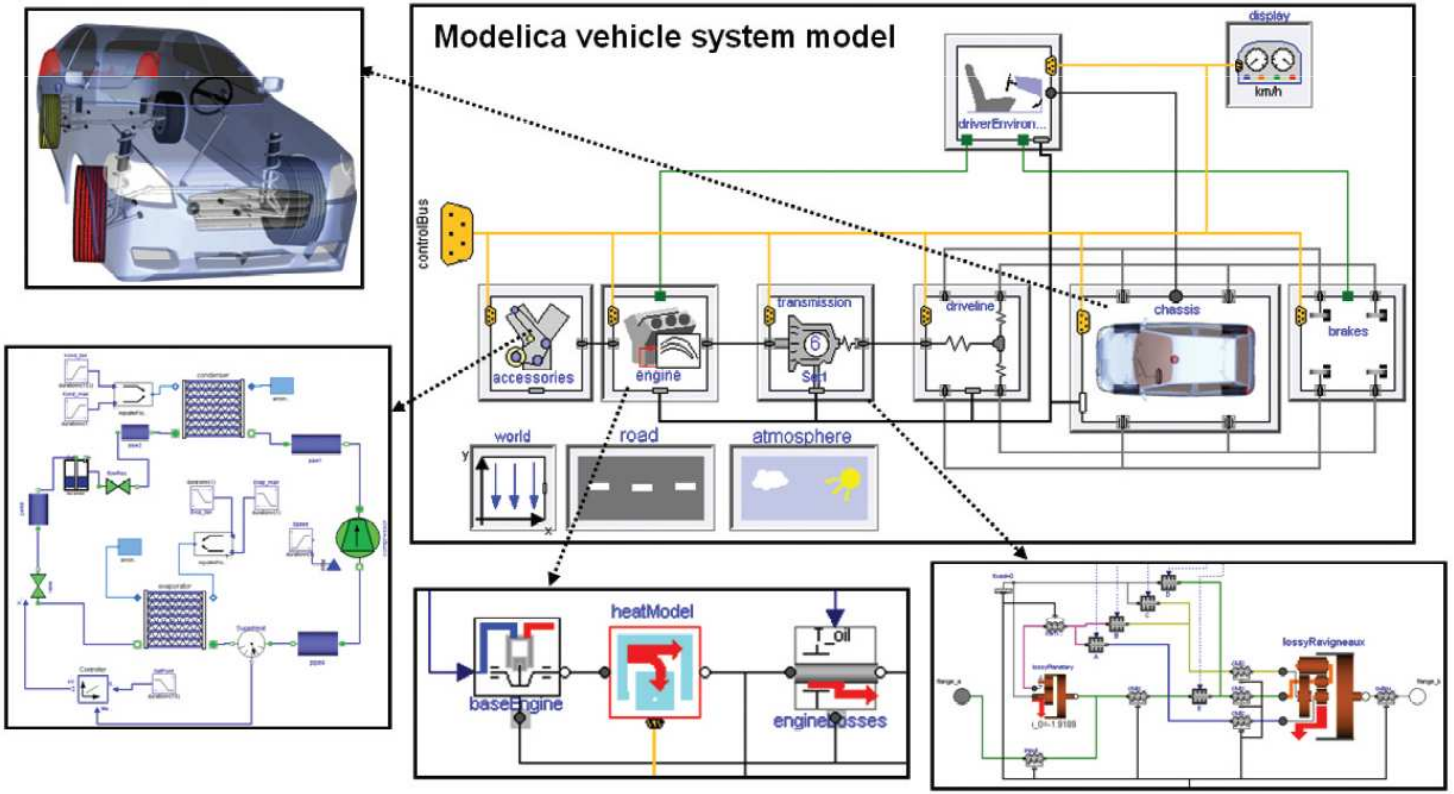


What is Modelica? (www.modelica.org)

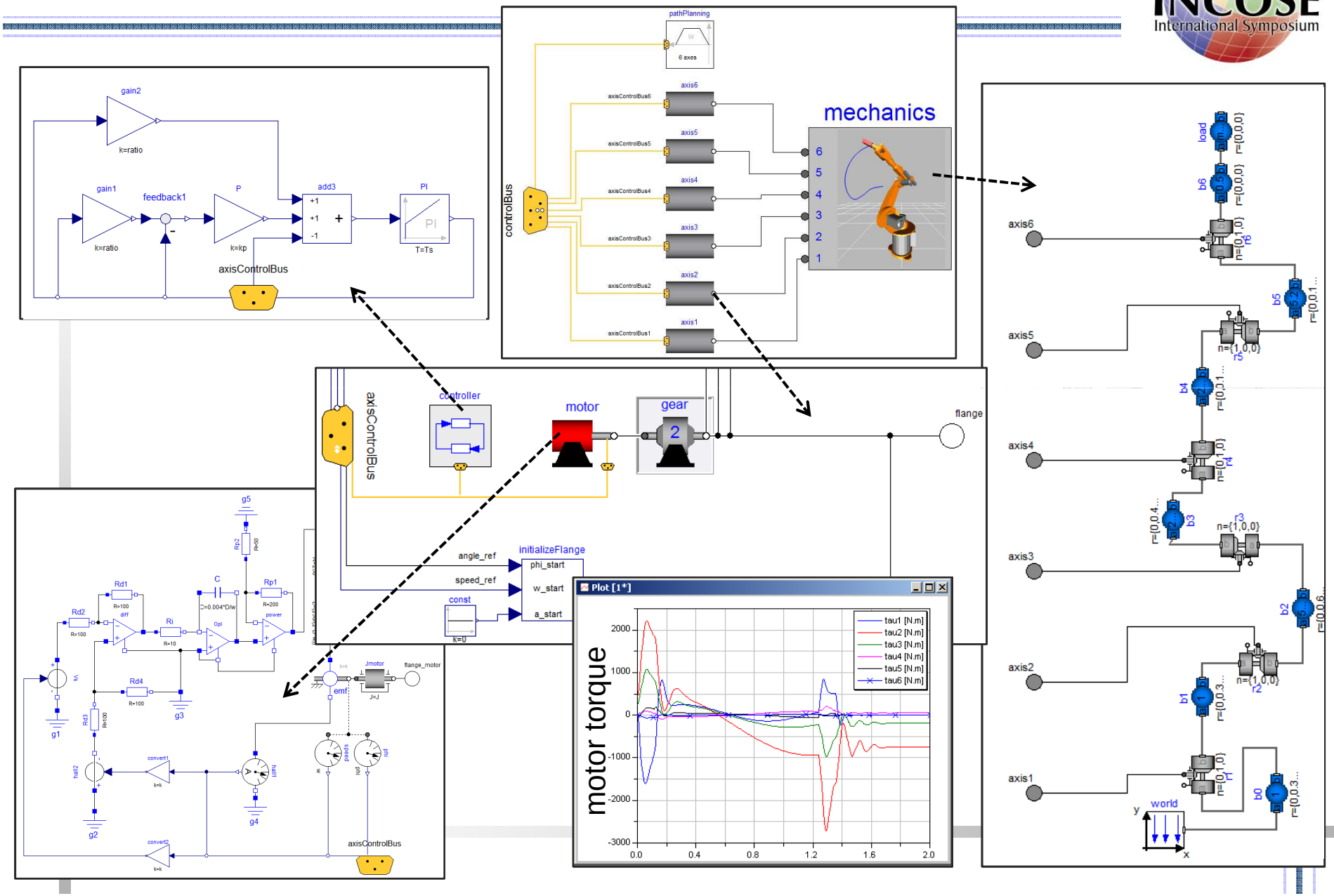
- State-of-the-art Modeling Language for System Dynamics
  - Differential Algebraic Equations (DAE)
  - Discrete Events
- Formal, object-oriented language
- Standardized by the Modelica Association
  - Open language specification – tool independent
- Multi-domain modeling
- Ports represent energy flow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



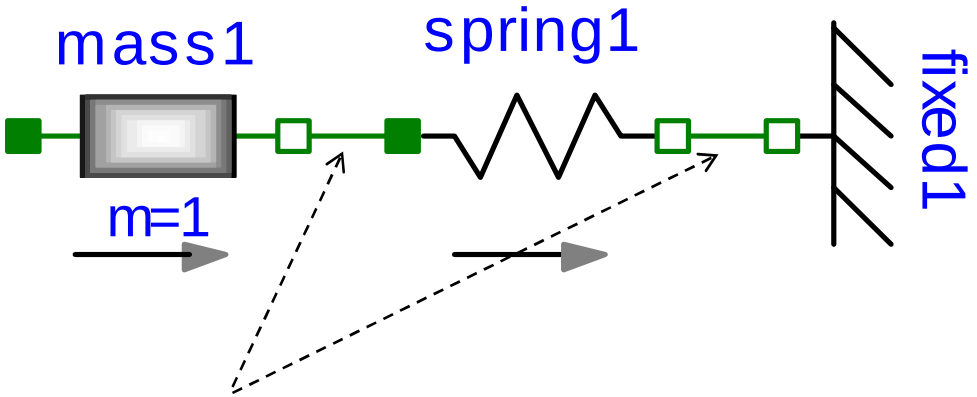
A Robot Example in Modelica



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 s_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

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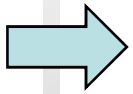

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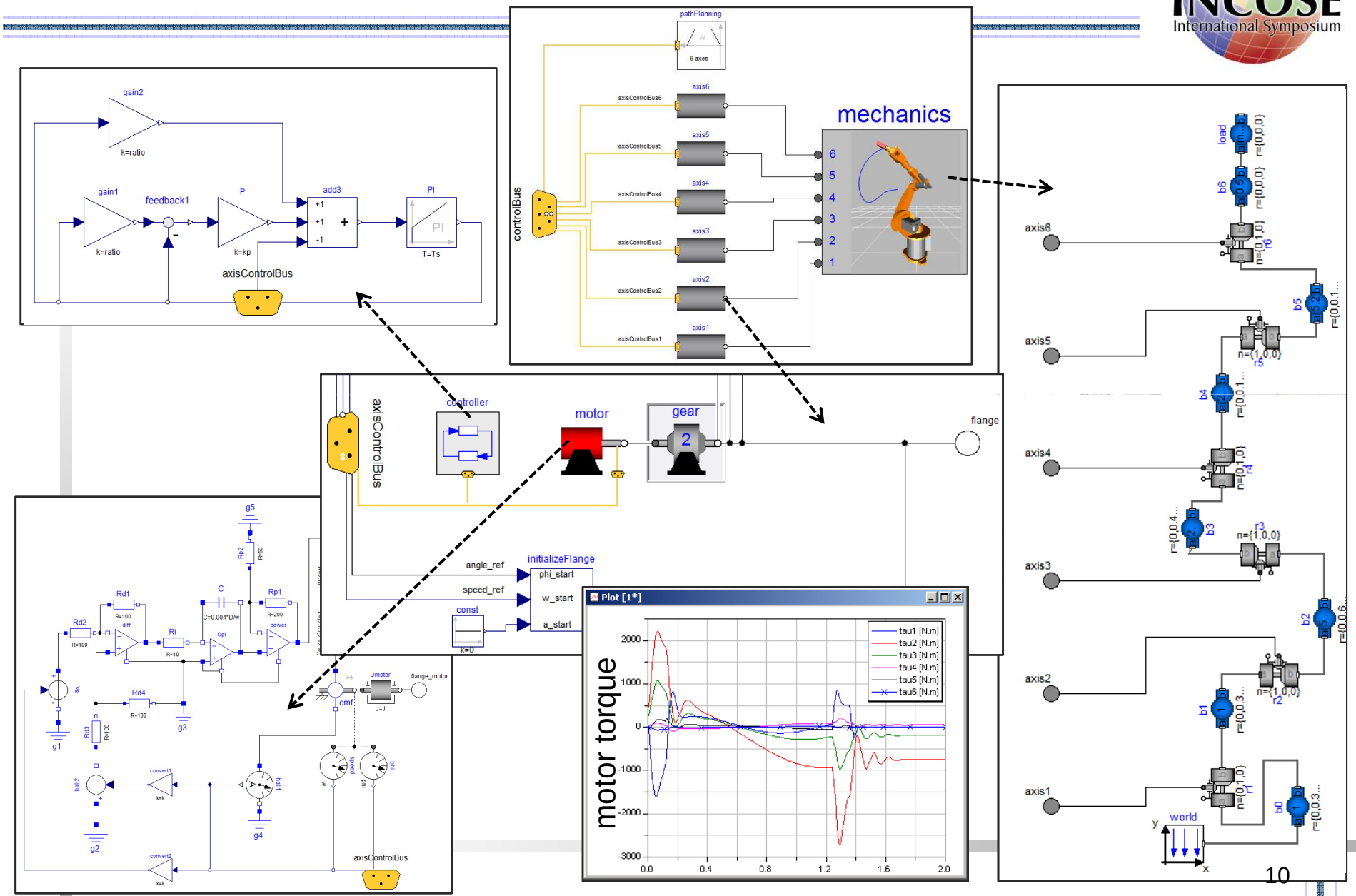
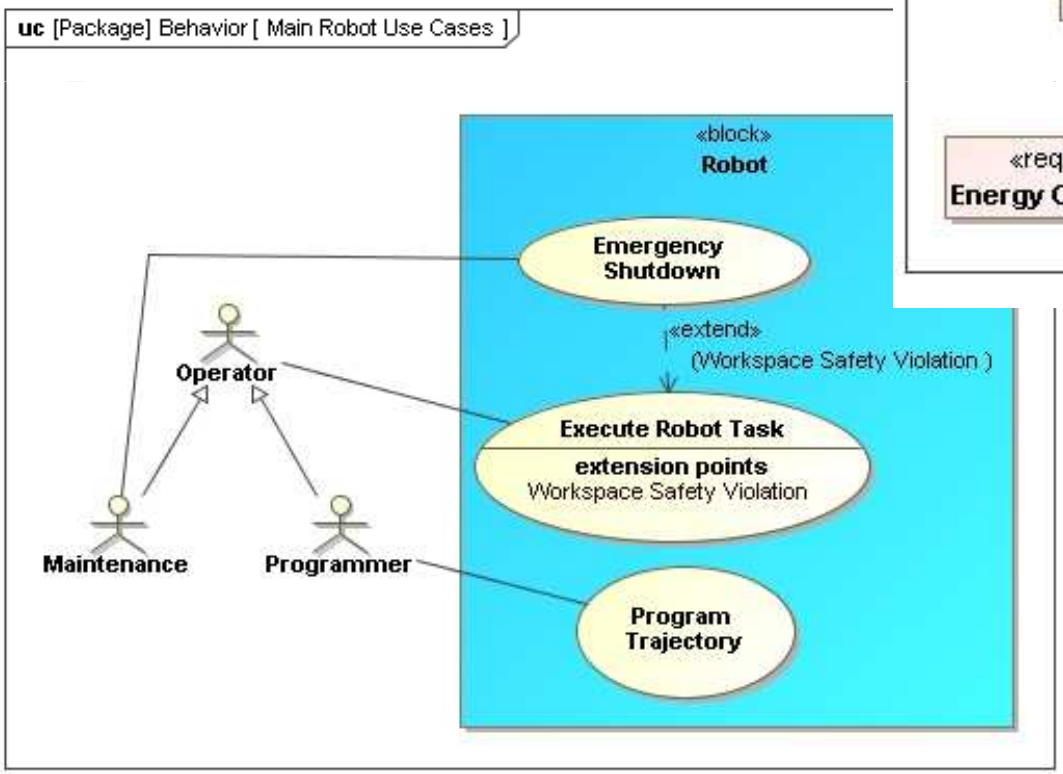
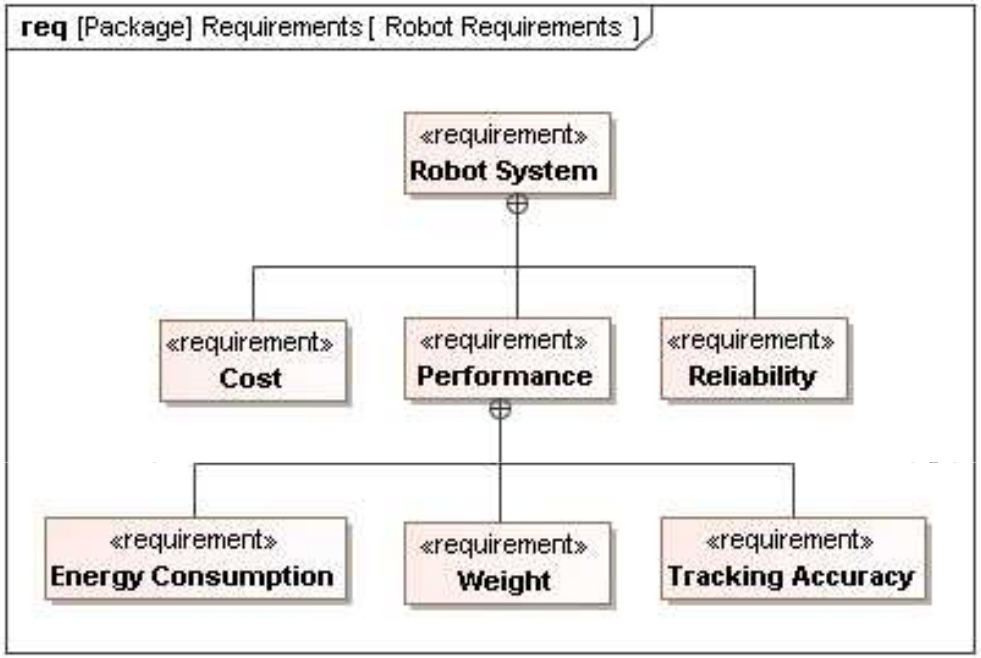
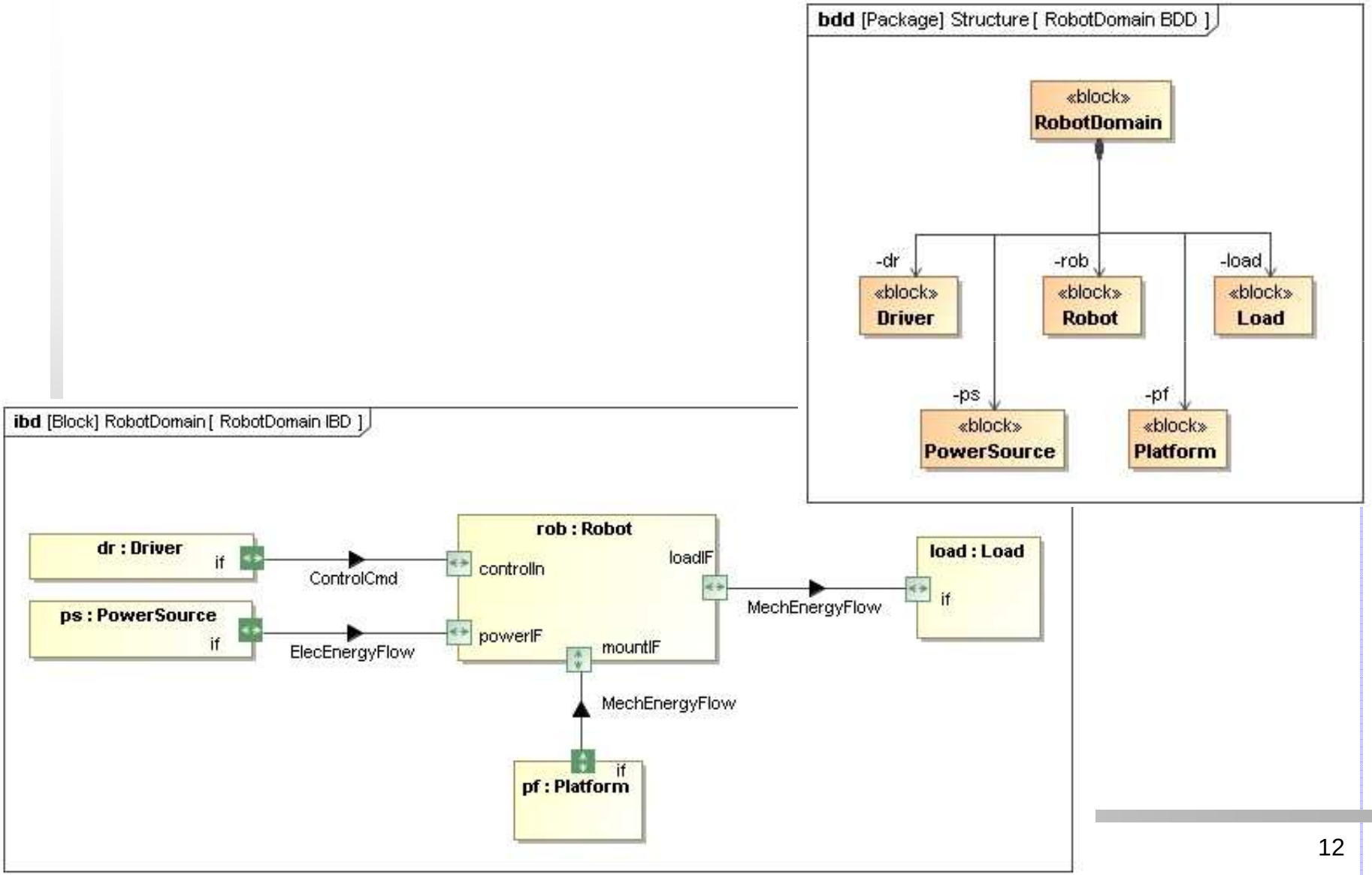


SysML-Modelica Robot Example: UseCases & Requirements





SysML-Modelica Robot Example: Robot Domain BDD & IBD



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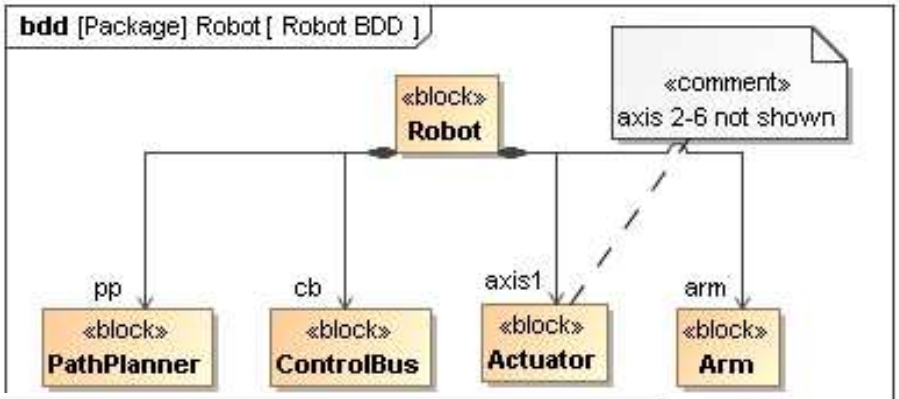
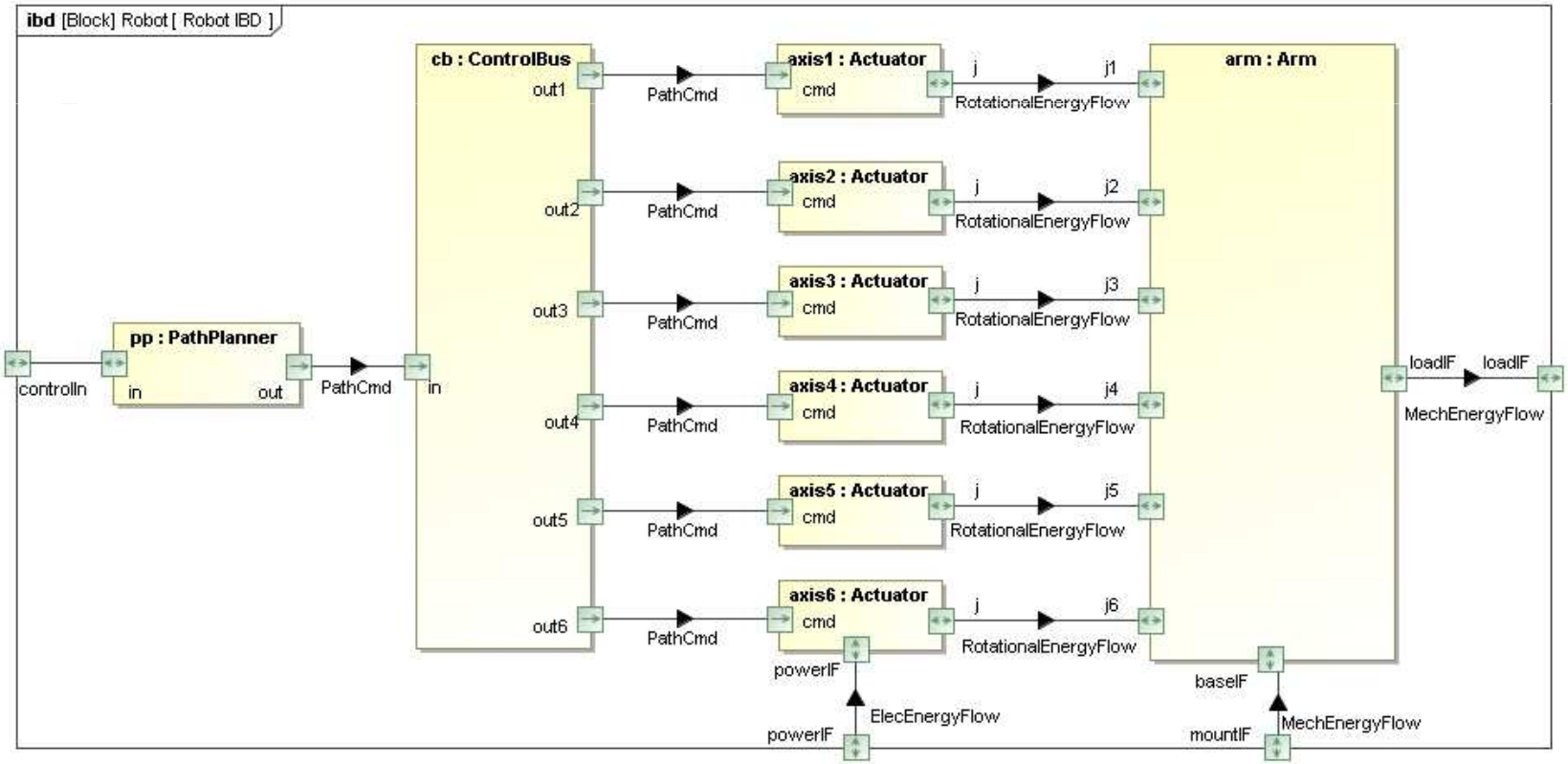
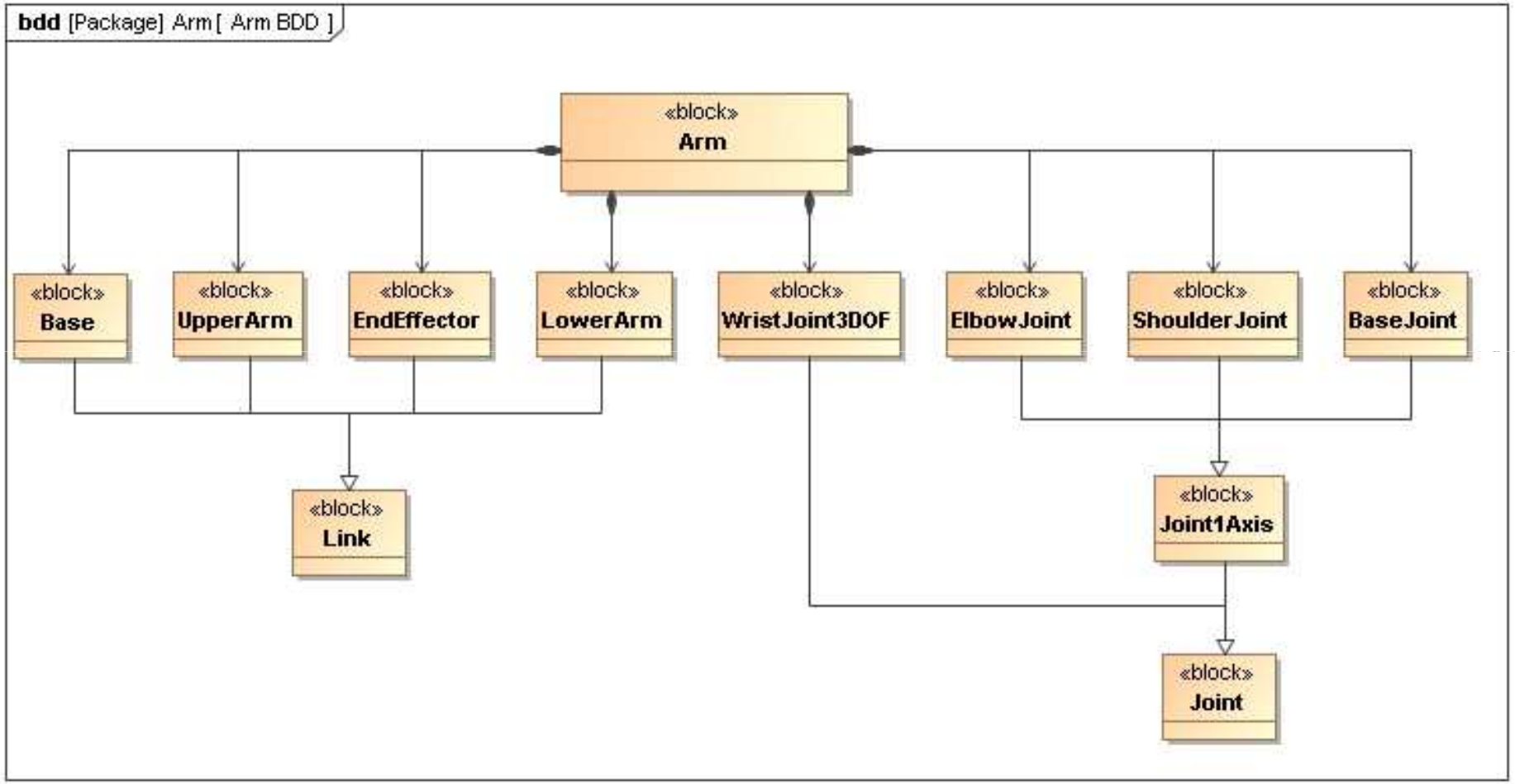
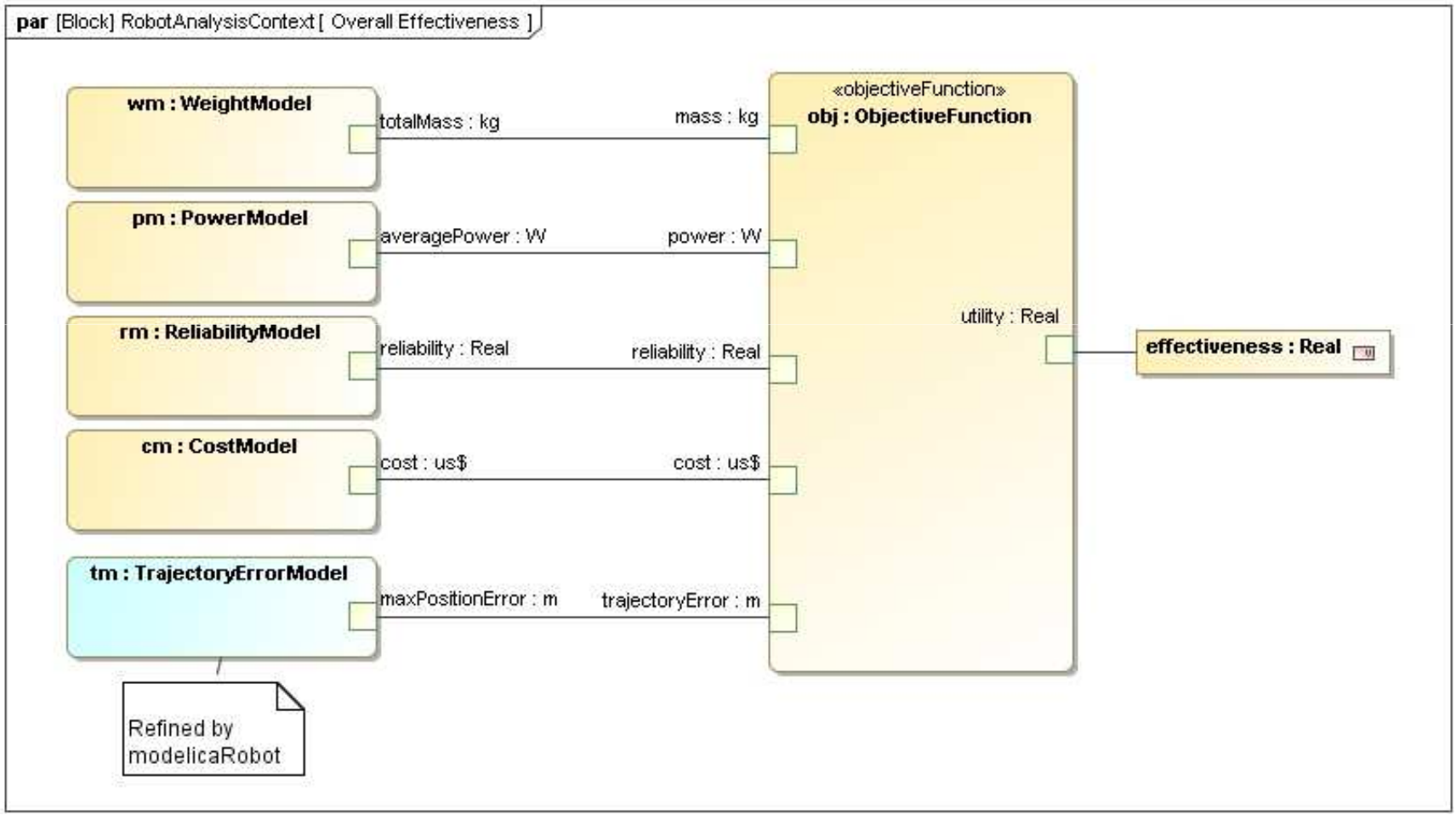




SysML-Modelica Robot Example: Robot Arm BDD

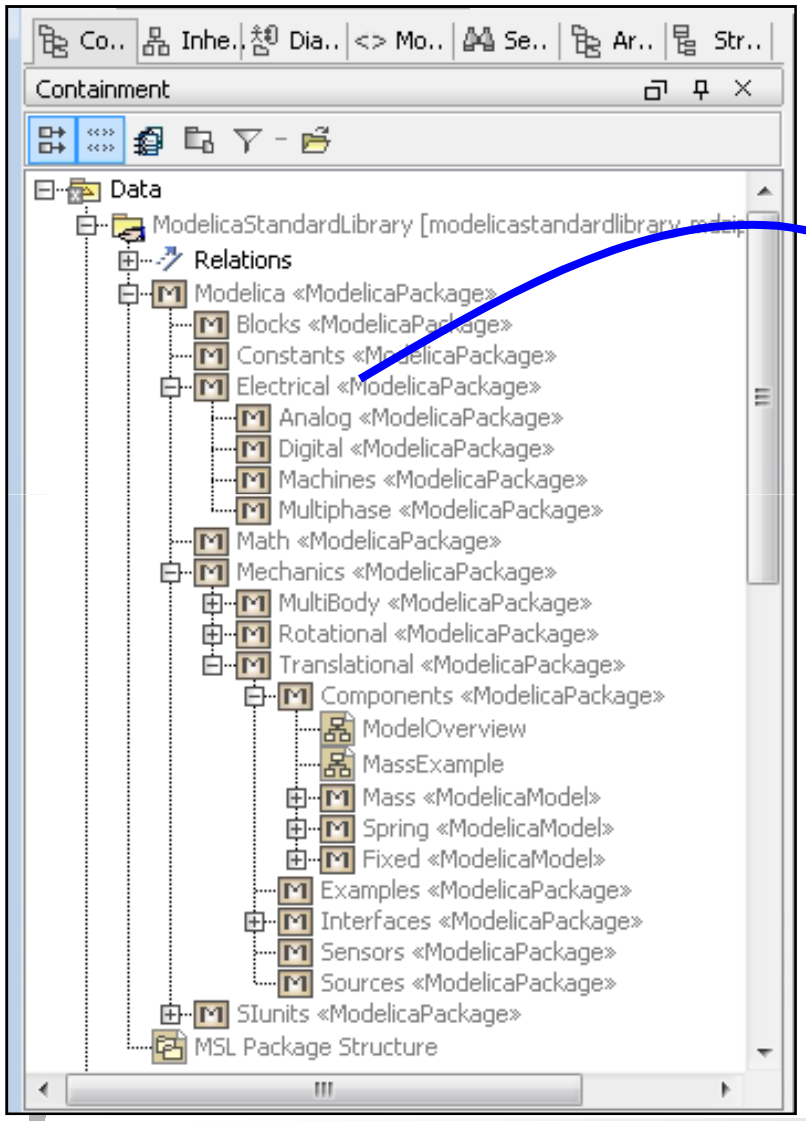


SysML-Modelica Robot Example: Analysis and Trade Study

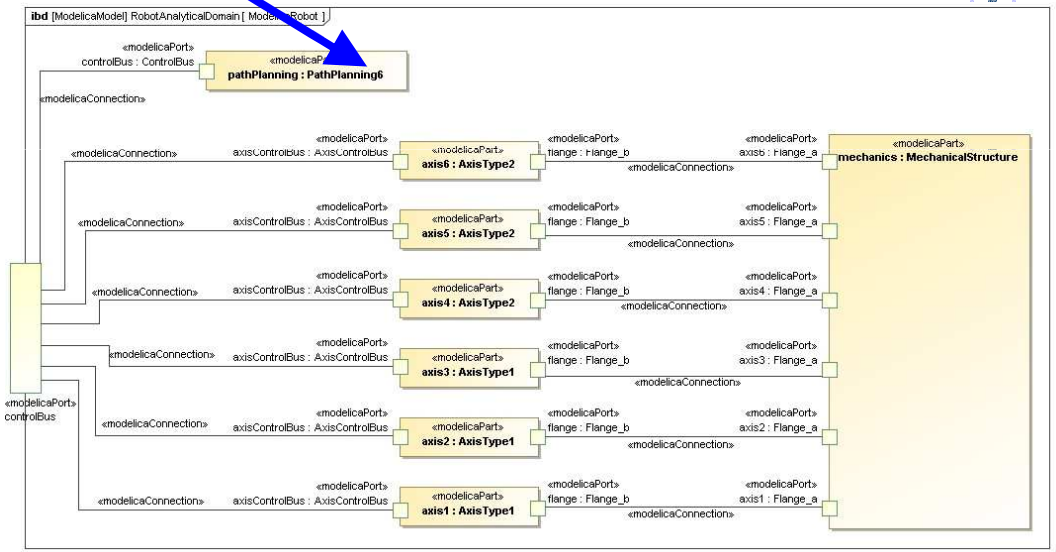


Analysis models depend on descriptive models

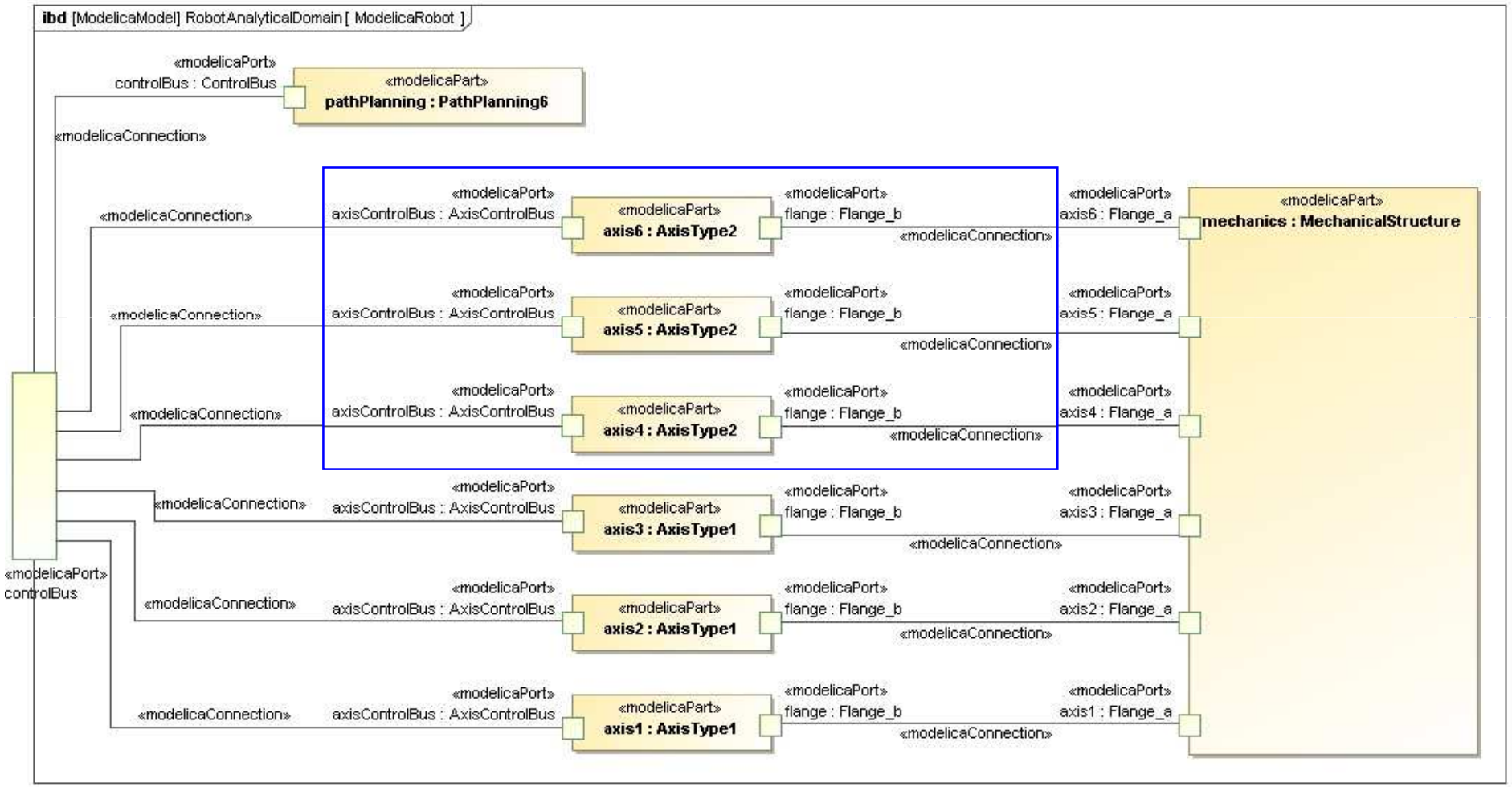
SysML4Modelica Analytical Model: Compose Model from SysML Standard Library



Drag and drop into IBD [ModelicaModel]



SysML4Modelica Analytical Model: Detailed IBD



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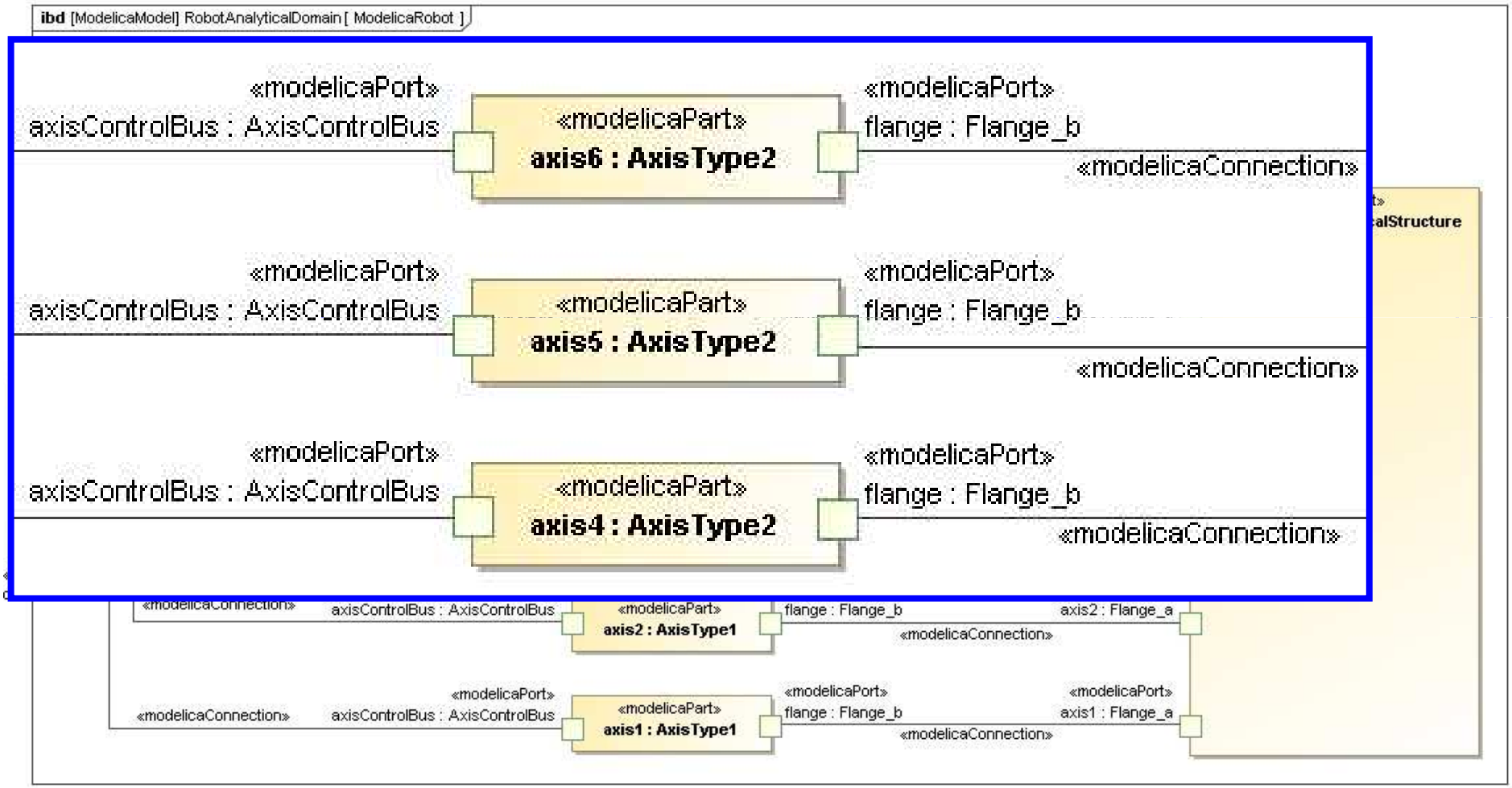
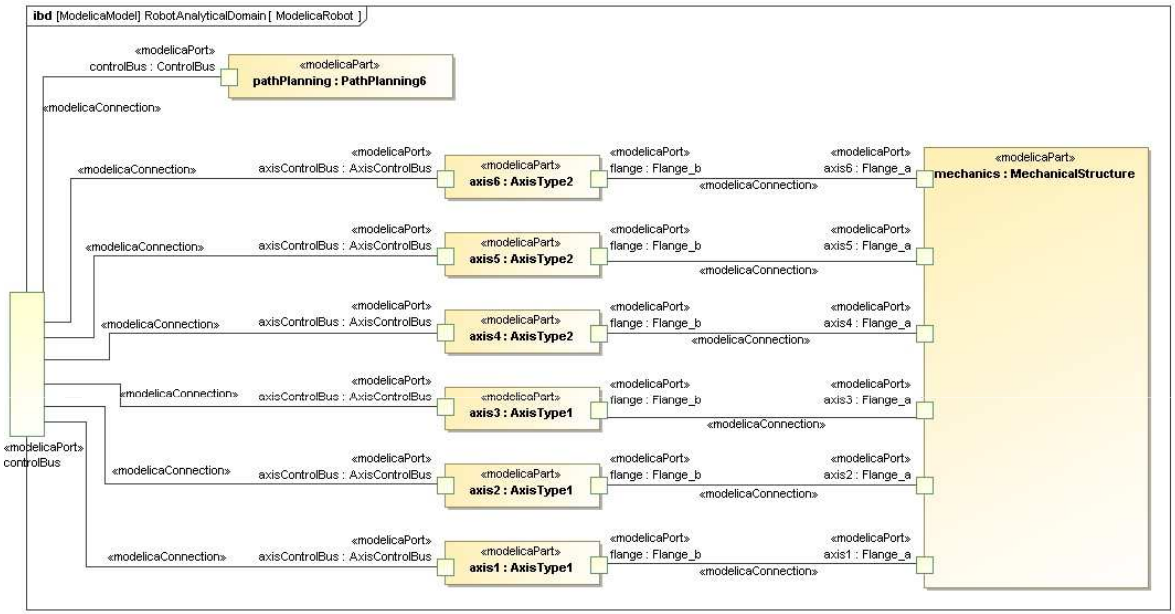
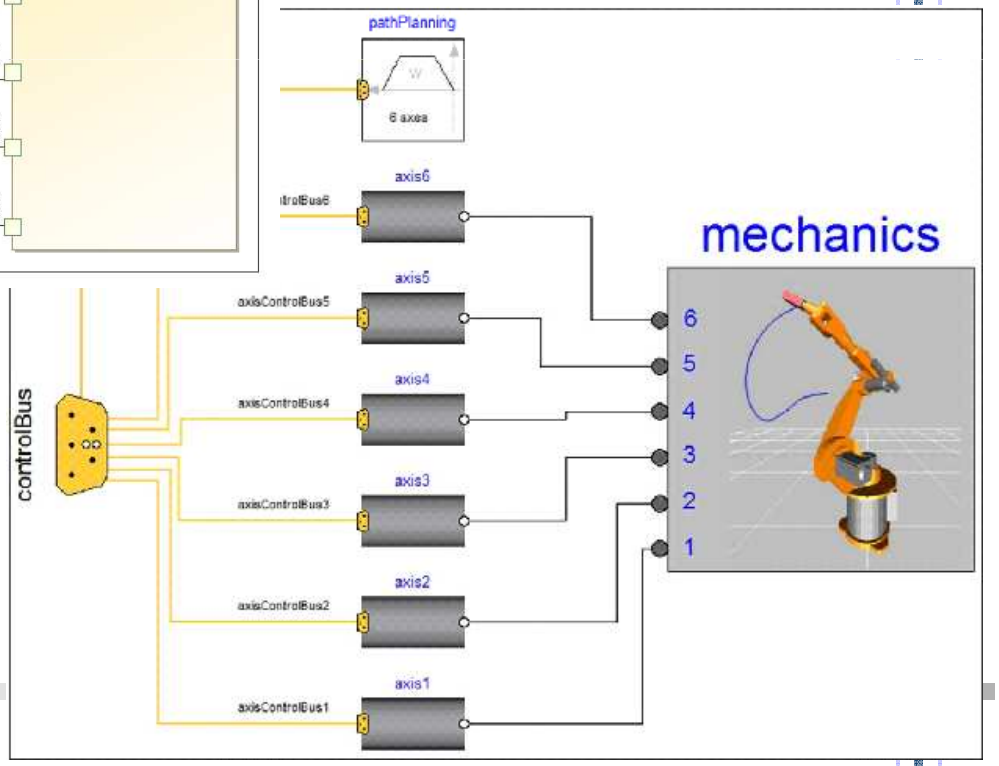
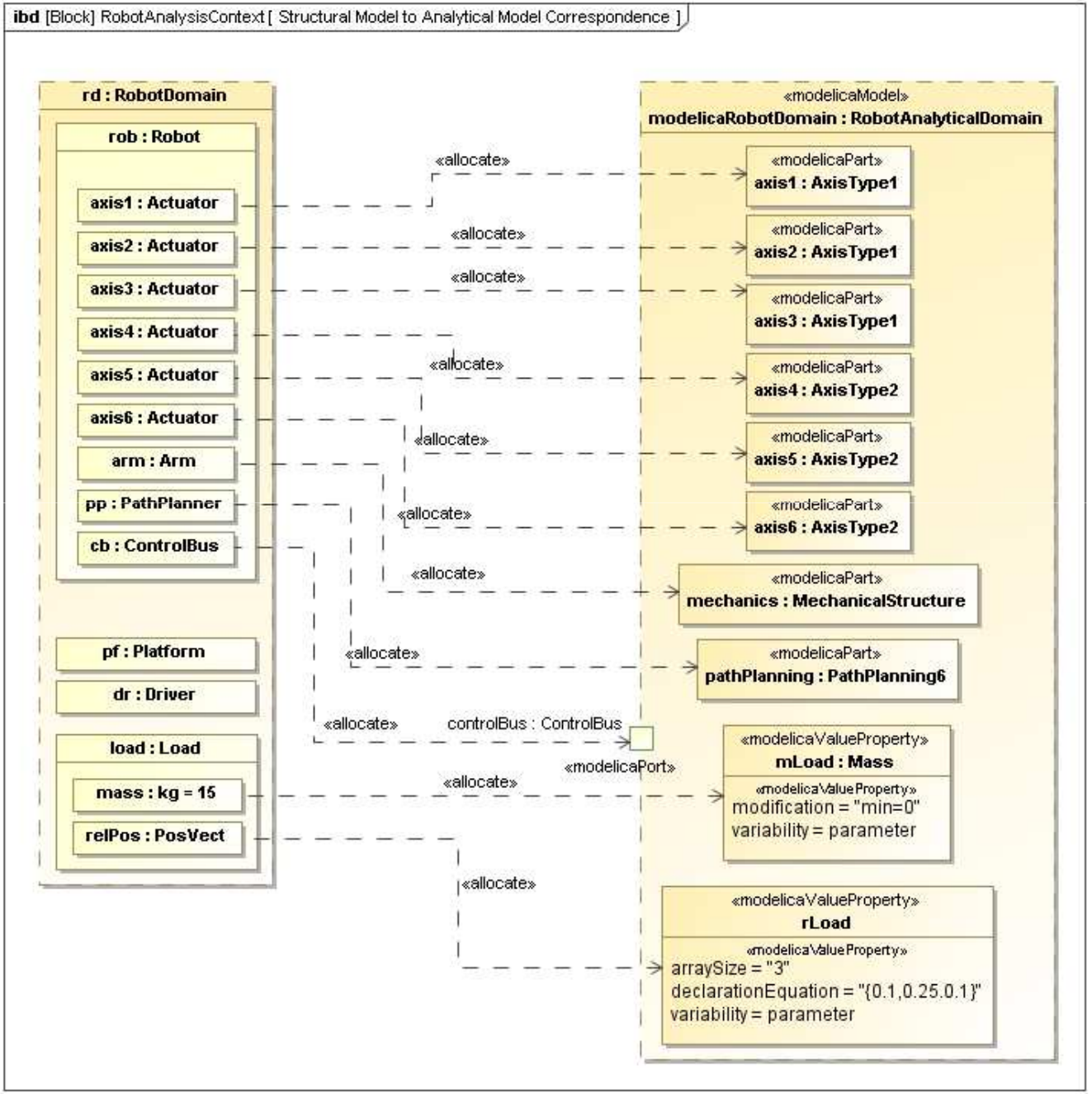


SysML4Modelica Analytical Model: Relation to Modelica Native Model

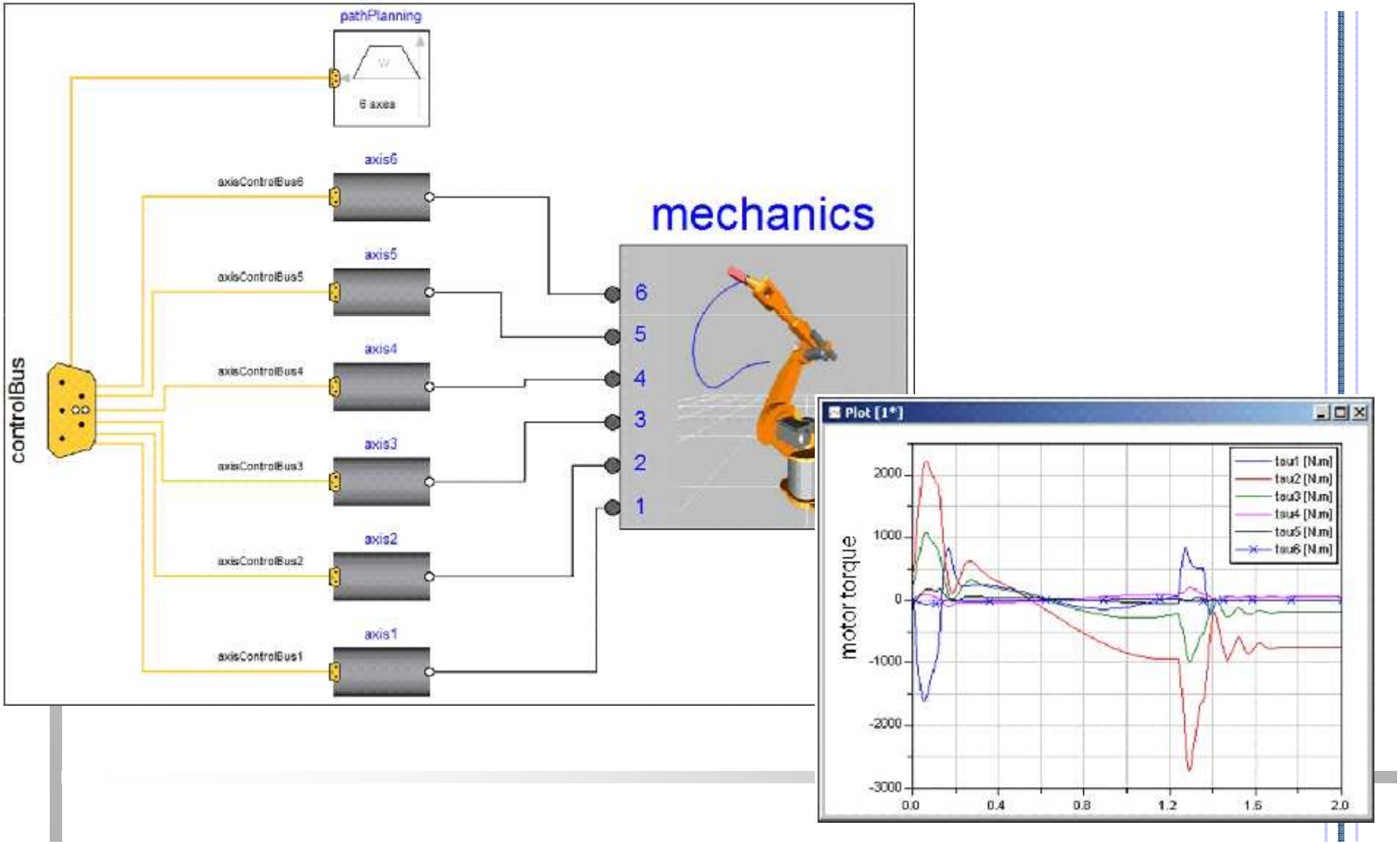




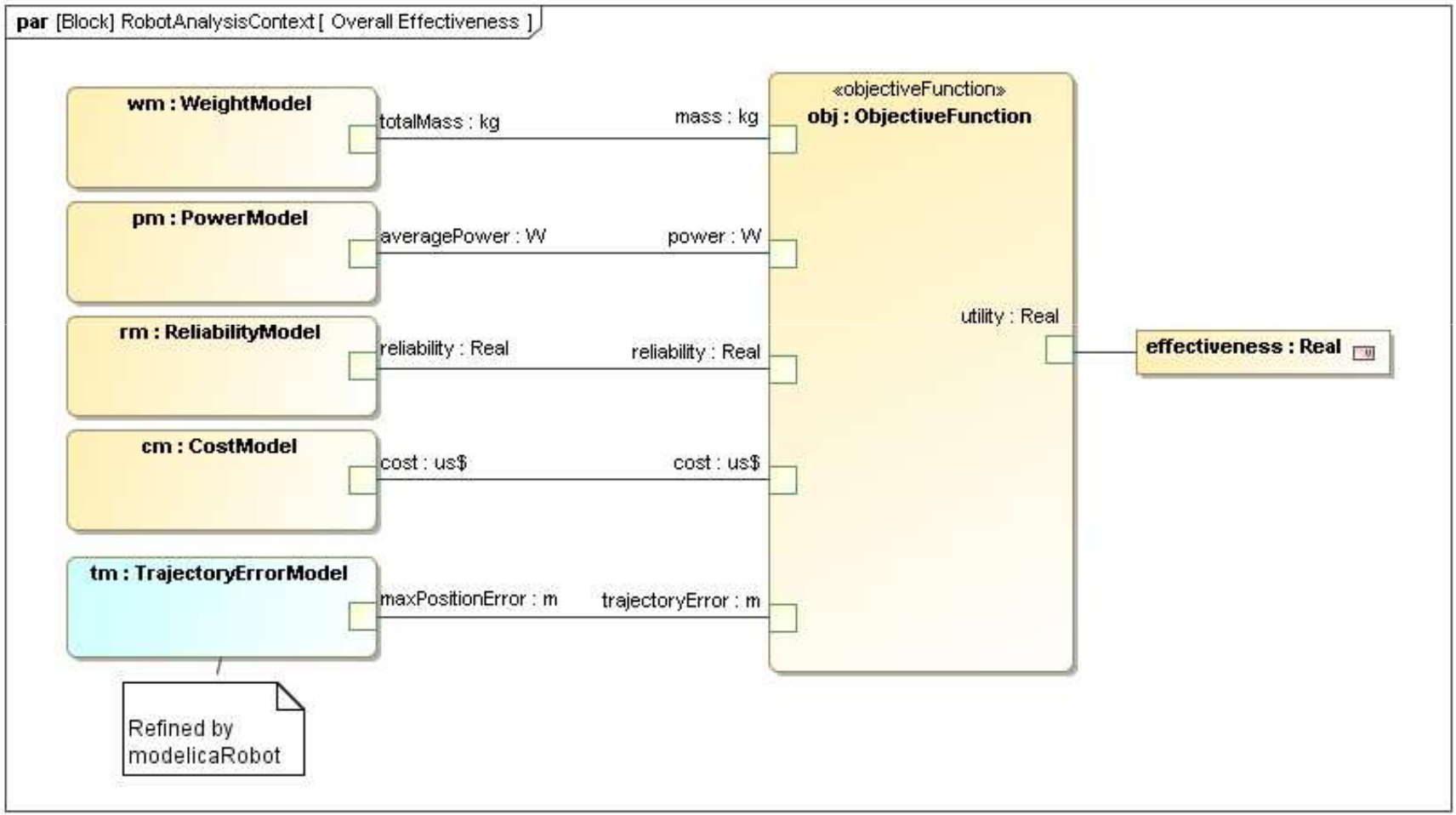
SysML4Modelica Analytical Model: Allocation



SysML-Modelica Robot Example: Modelica model with simulation results



SysML-Modelica Robot Example: Analysis and Trade Study



Analysis results are incorporated in Trade Study

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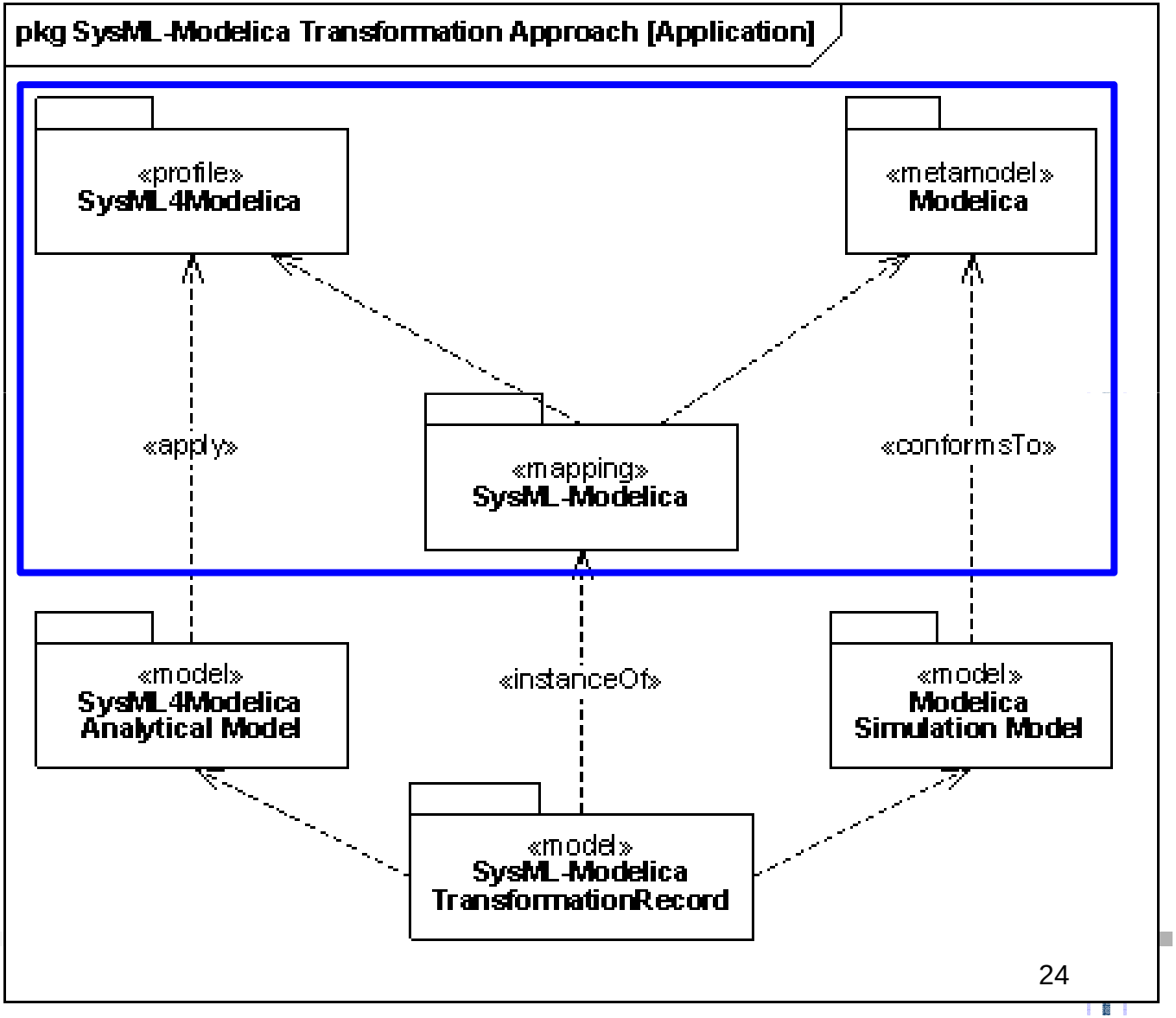
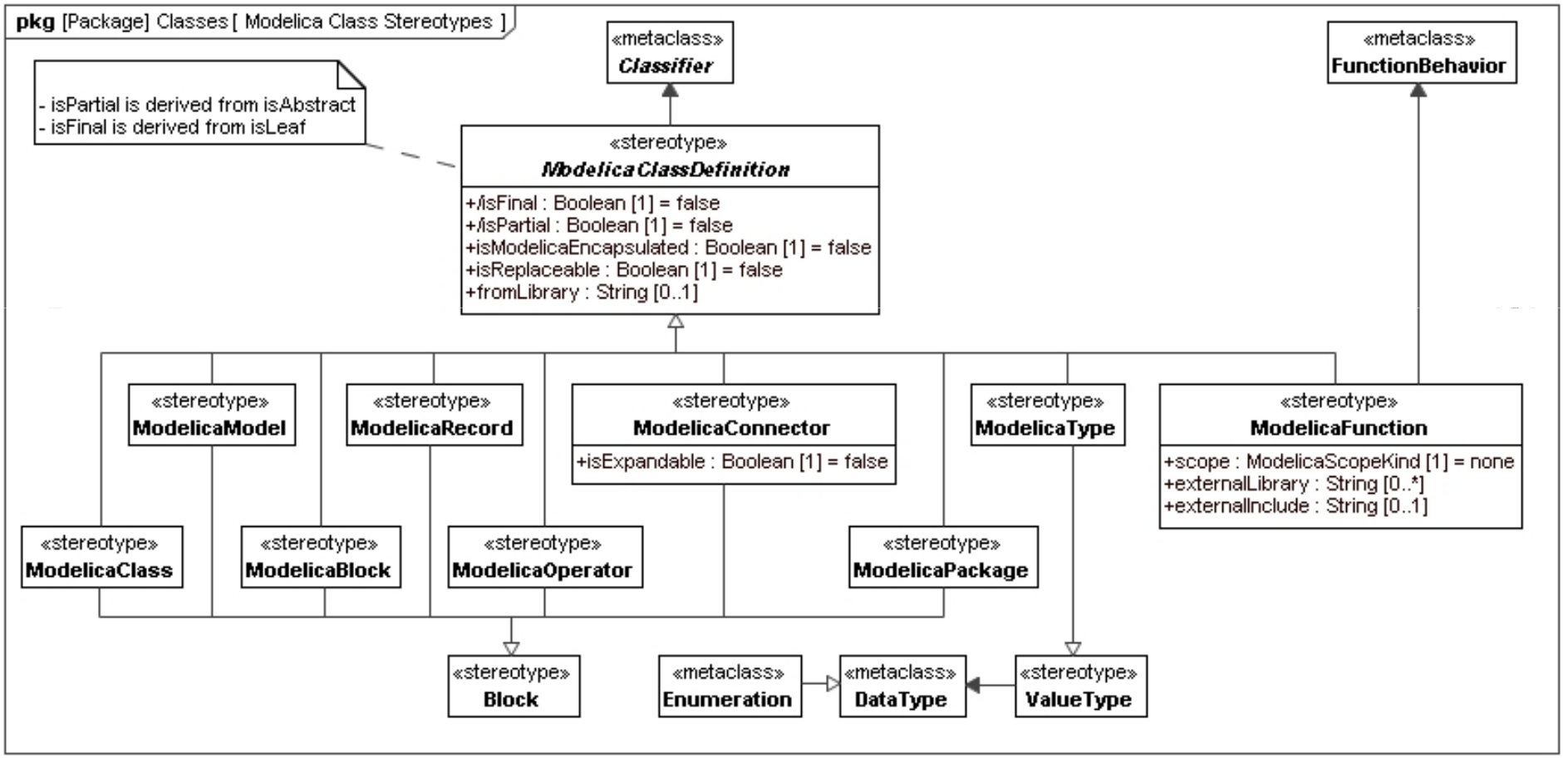
SysML-Modelica Transformation Specification

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



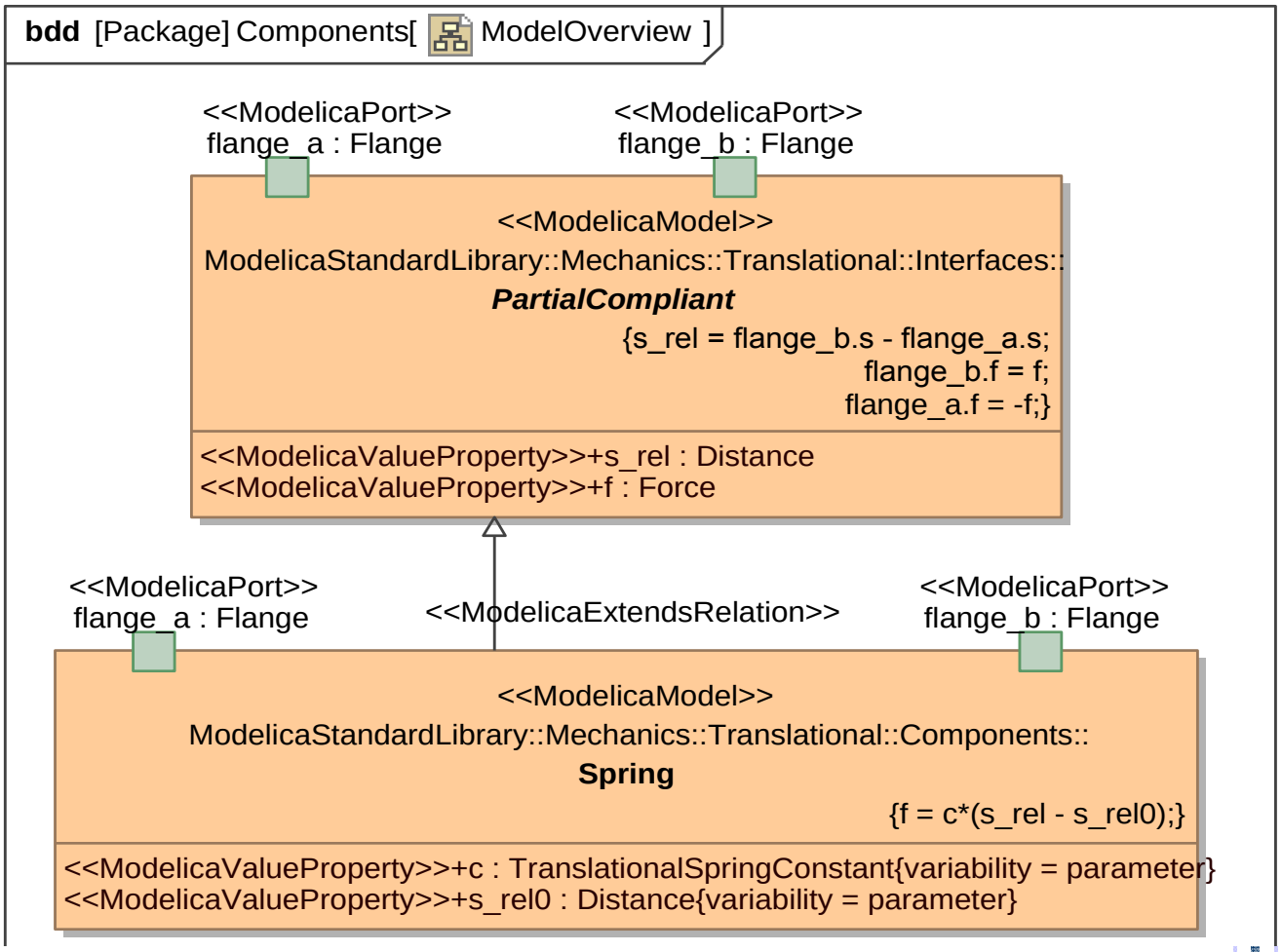
SysML4Modelica Profile



SysML4Modelica

Formal mapping

Modelica

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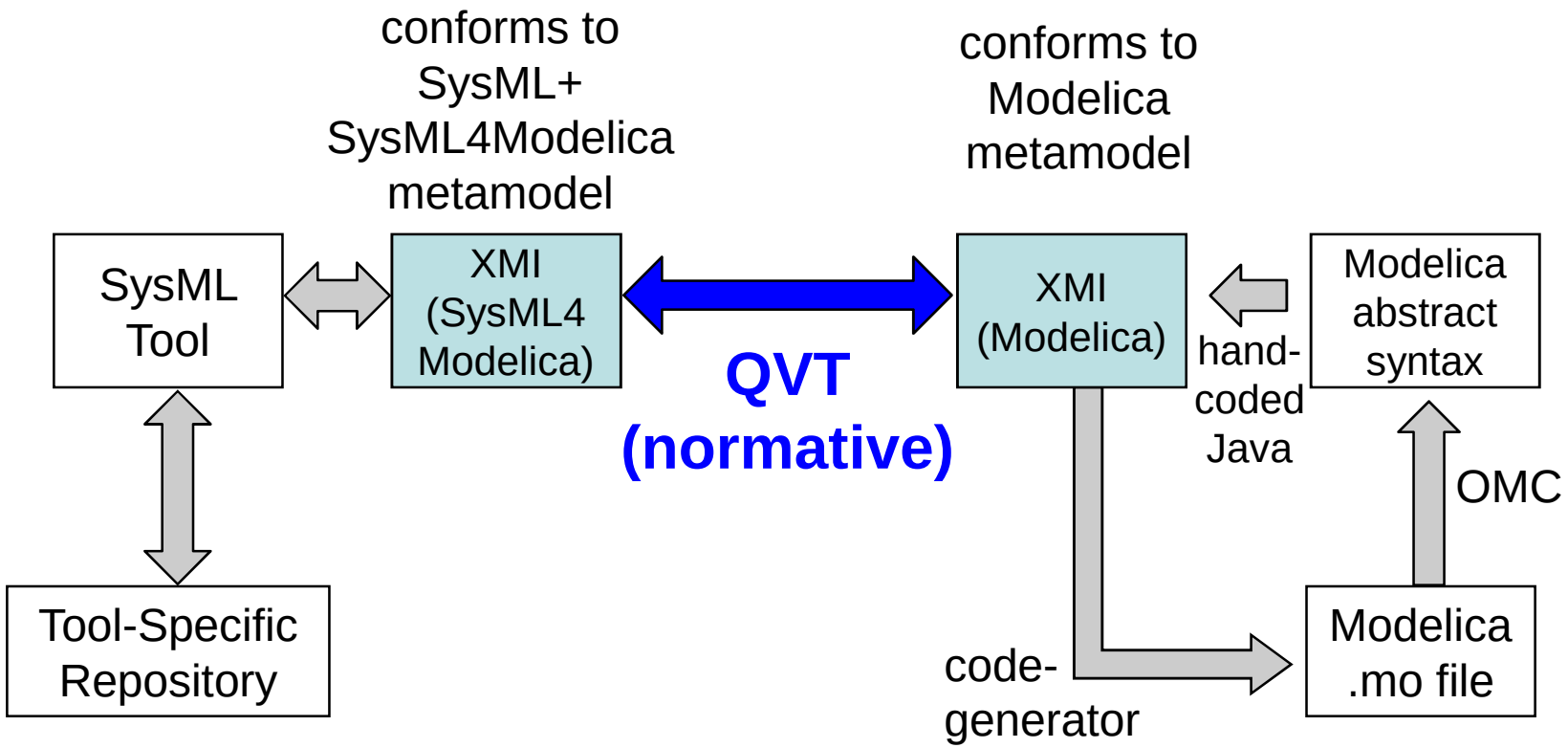
    "spring constant ";
  parameter SI.Distance s_rel0=0 "unstretched spring length";

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

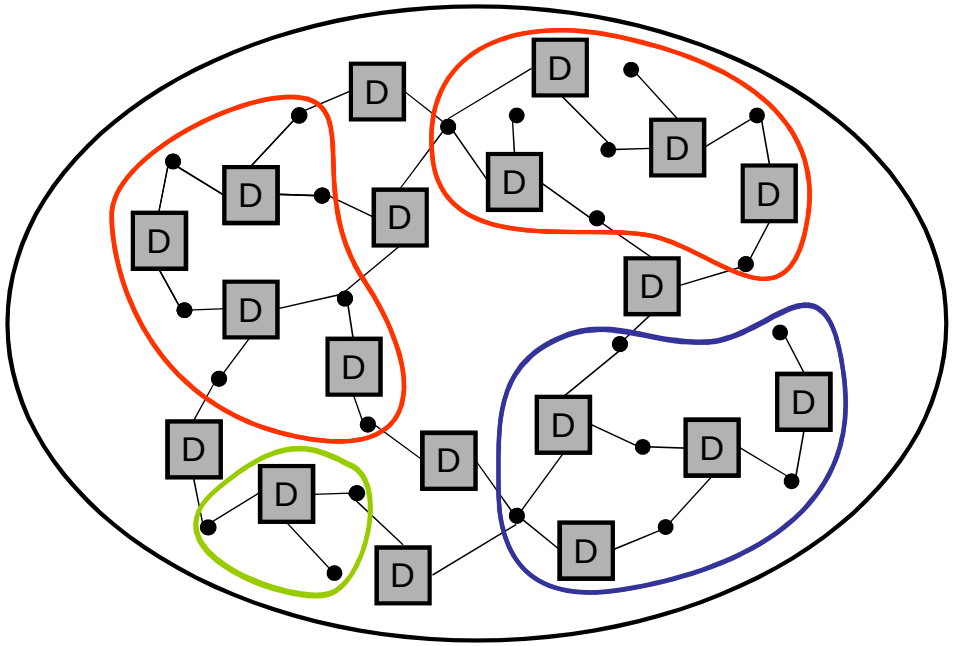
Reference implementation: Based on OMG QVT



QVT = Query / View / Transformation

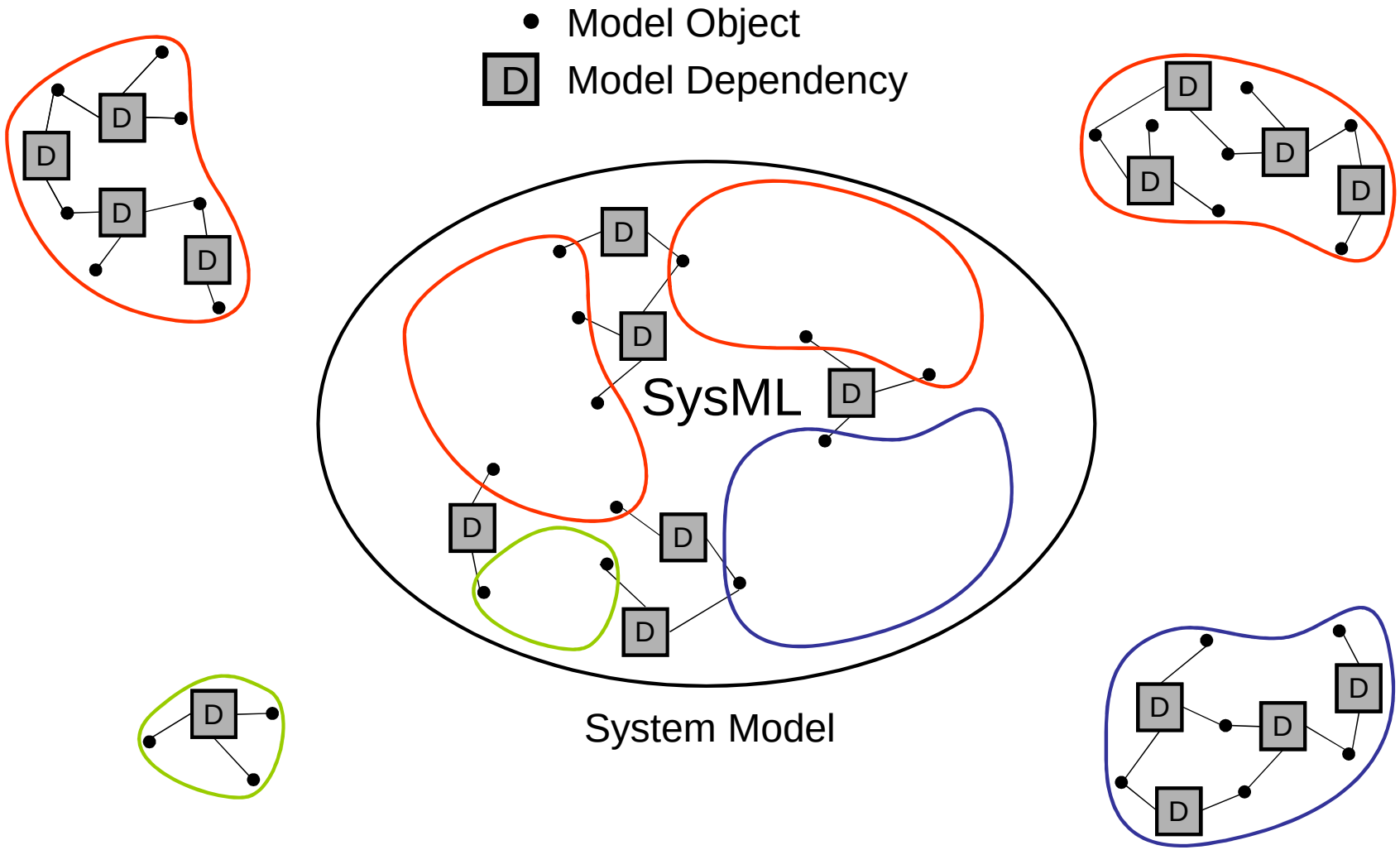
Transformations in Systems Modeling

- Model Object
- D Model Dependency

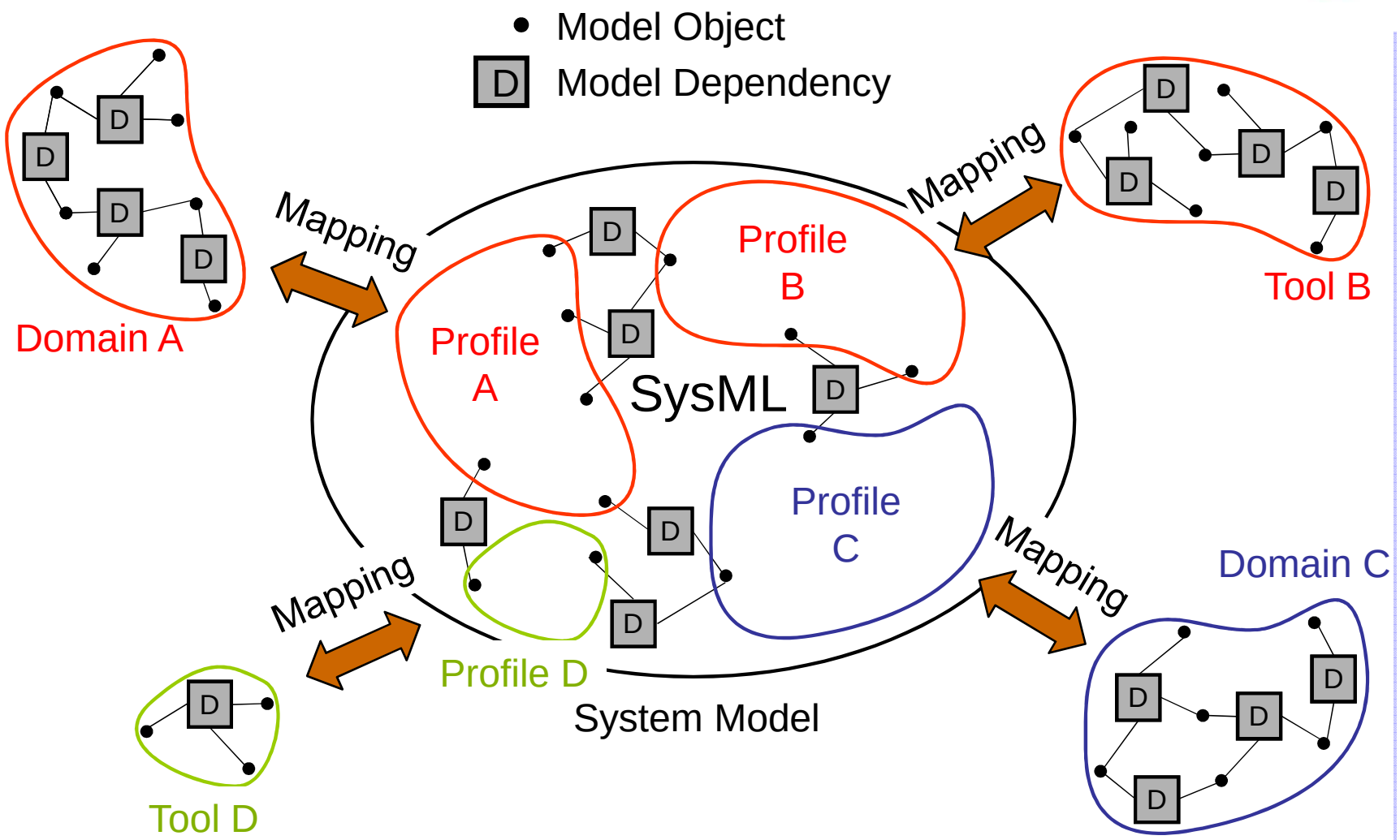


System Model

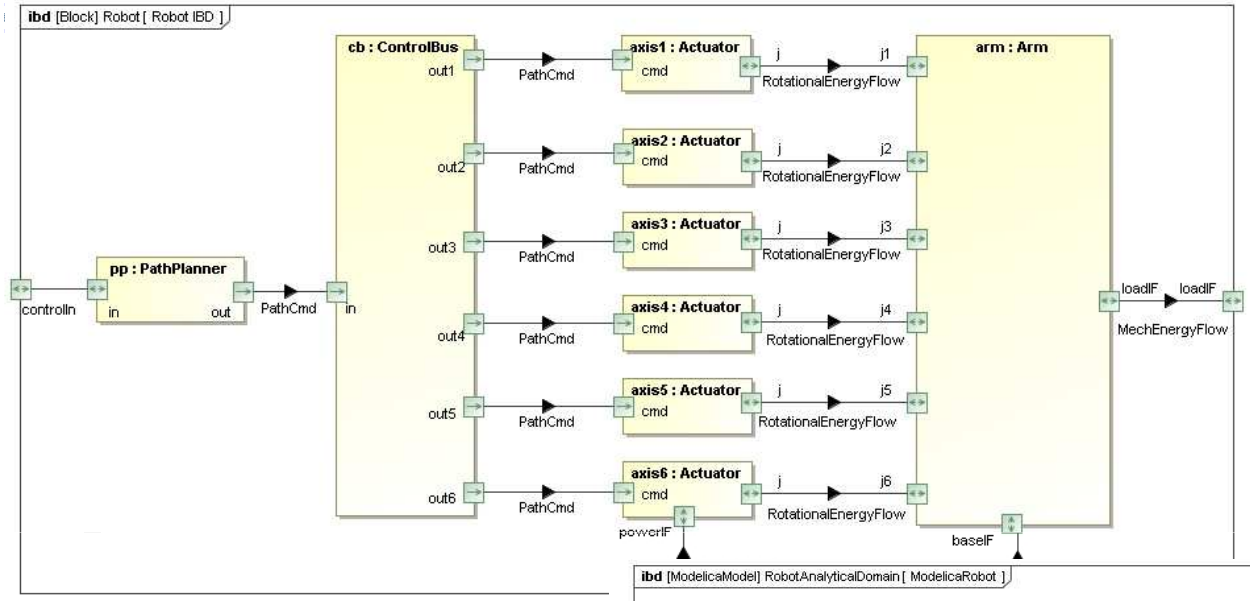
Transformations in Systems Modeling

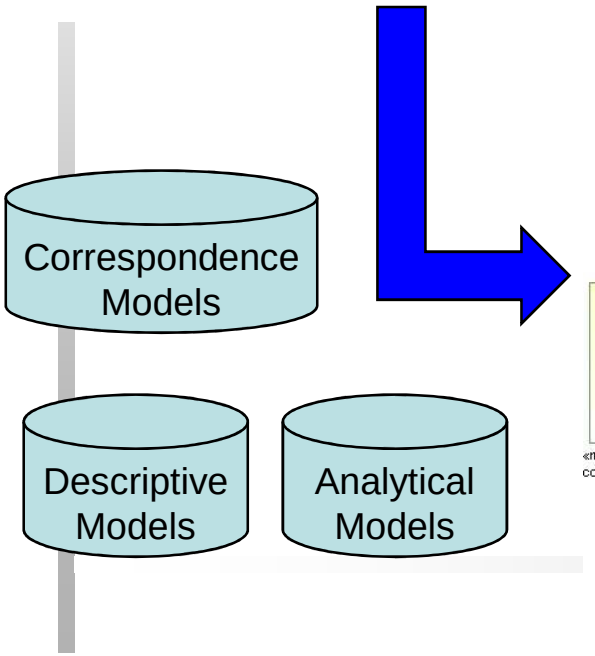


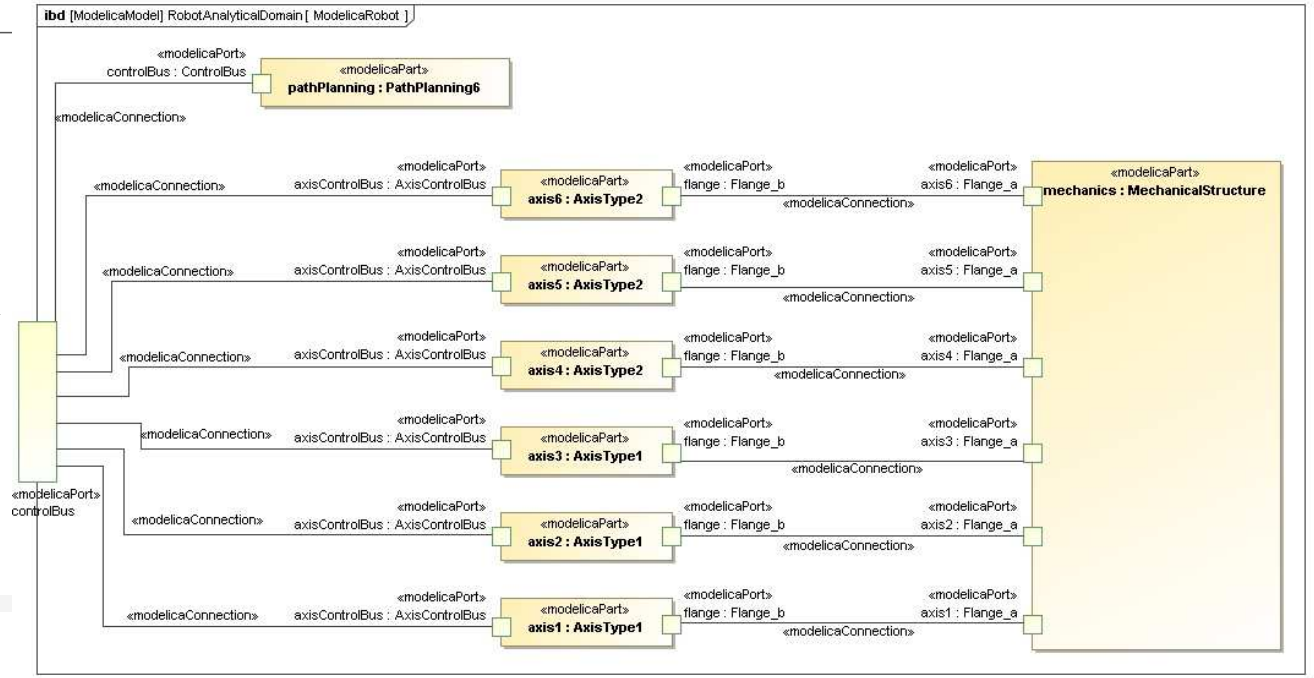
Transformations in Systems Modeling



Descriptive to Analytical Transformation







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 (?)

Summary

- 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

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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)
- Chris Paredis (Georgia Tech)
- Axel Reichwein (Georgia Tech)
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