



# **Model Based Systems Engineering using SysML**

**Overview and Status  
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# Topics

- **MBSE Motivation and Scope**
- **System Modeling Using SysML**
- **System Model as an Integration Framework**
- **SysML Status**
- **MBSE Observations**
- **Summary**

# **MBSE Motivation and Scope**

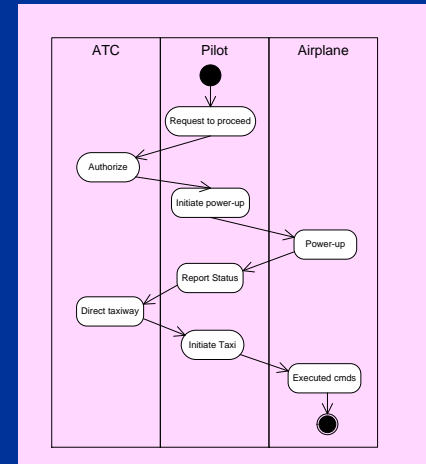
# SE Practices for Describing Systems

*Past*



- Specifications
- Interface requirements
- System design
- Analysis & Trade-off
- Test plans

*Future*

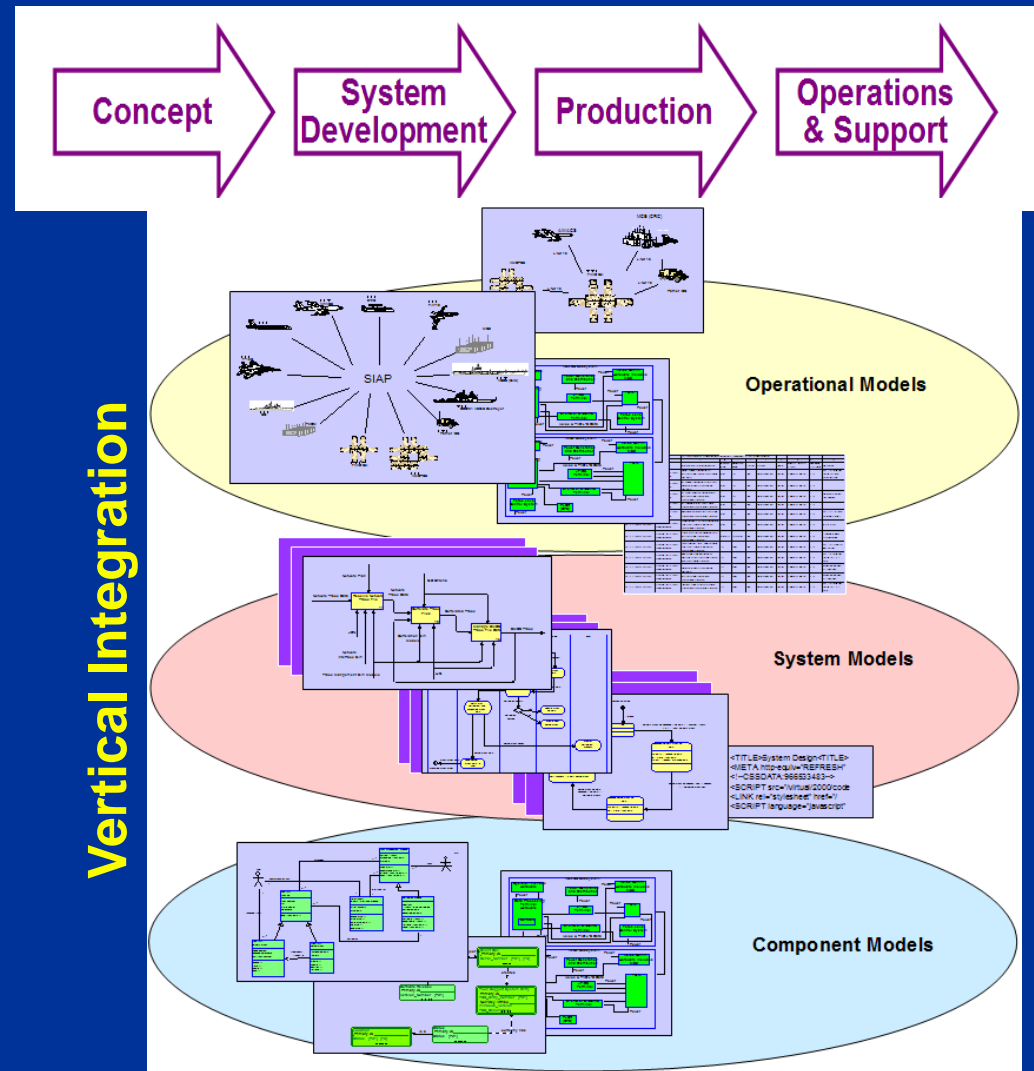


Moving from Document centric to Model centric

# Model-based Systems Engineering (MBSE)

- Formalizes the practice of systems engineering through use of models
- Broad in scope
  - Integrates with multiple modeling domains across life cycle from SoS to component
- Results in quality/productivity improvements & lower risk
  - Rigor and precision
  - Communications among system/project stakeholders
  - Management of complexity

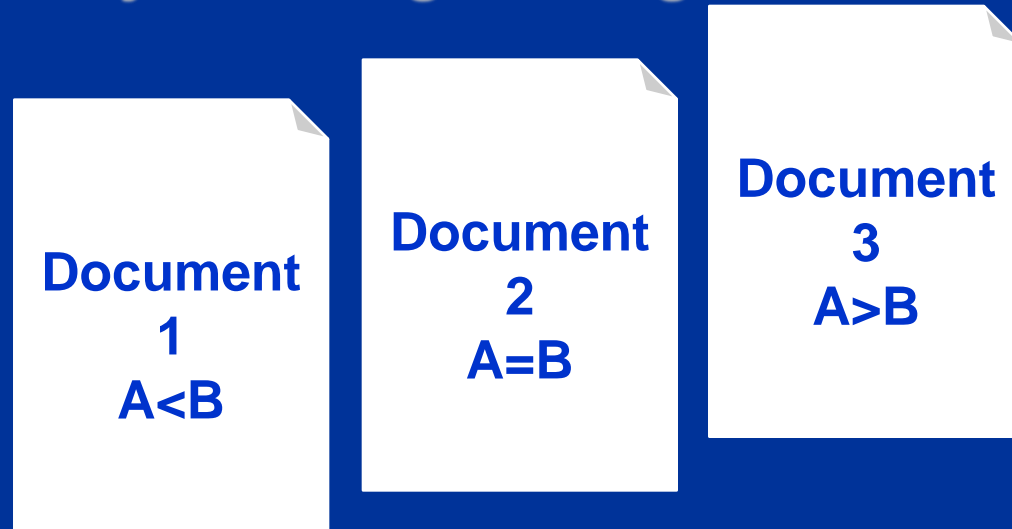
## Life Cycle Support



# System Description

- *Document-Based System Engineering:*

**Where is truth?**



**Inconsistencies within and among documents**

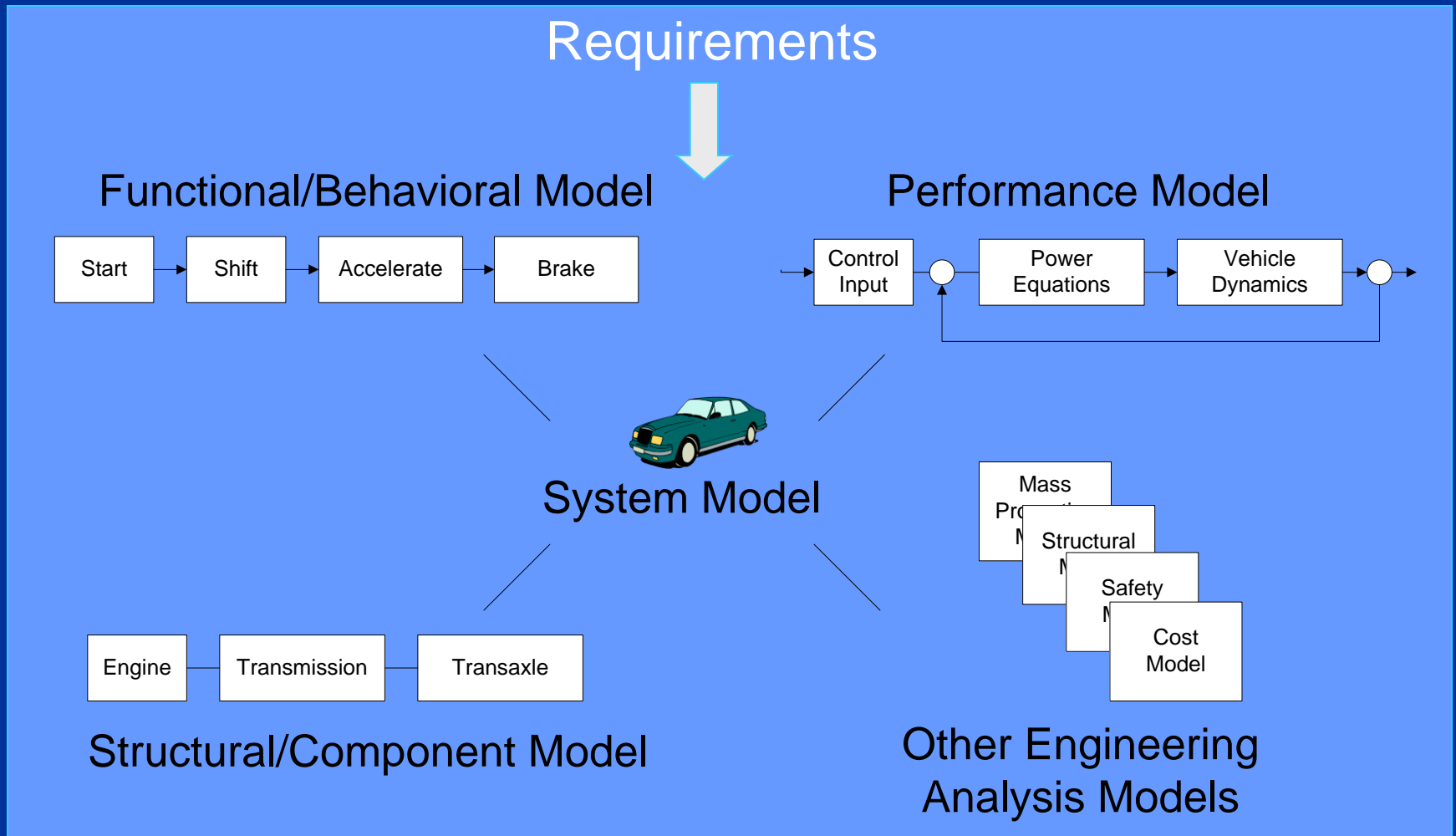
- *Model-Based System Engineering:*



**Model enforces consistency**

# **System Modeling Using SysML**

# System Modeling



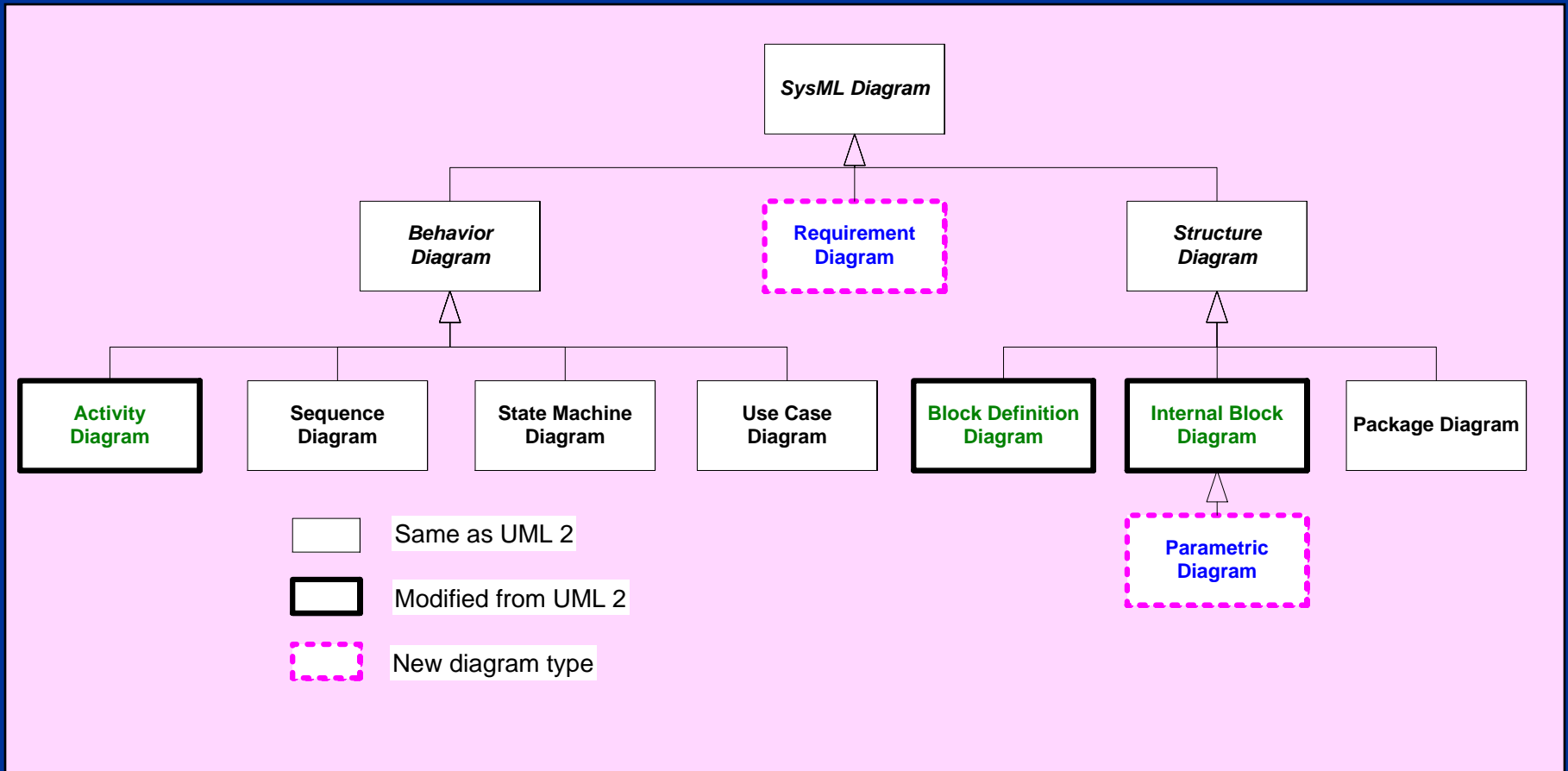
**Integrated System Model Must Address  
Multiple Aspects of a System**

# What is SysML?

- **A graphical modeling language in response to the UML for Systems Engineering RFP developed by the OMG, INCOSE, and AP233**
  - a UML Profile that represents a subset of UML 2 with extensions
- **Supports the specification, analysis, design, verification, and validation of systems that include hardware, software, data, personnel, procedures, and facilities**
- **Supports model and data interchange via XML Metadata Interchange (XMI®) and the evolving AP233 standard (in-process)**

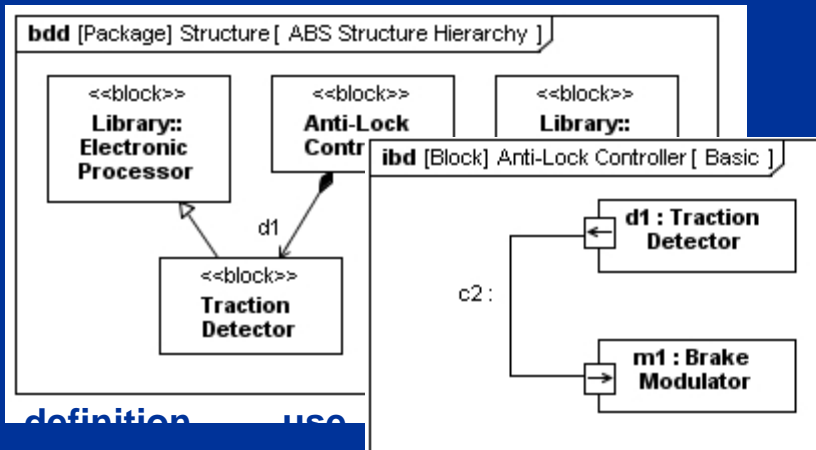
**SysML is Critical Enabler for MBSE**

# SysML Diagram Taxonomy

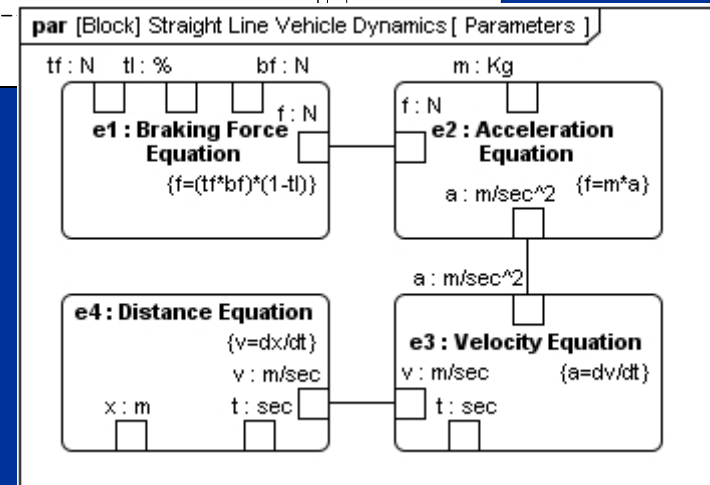
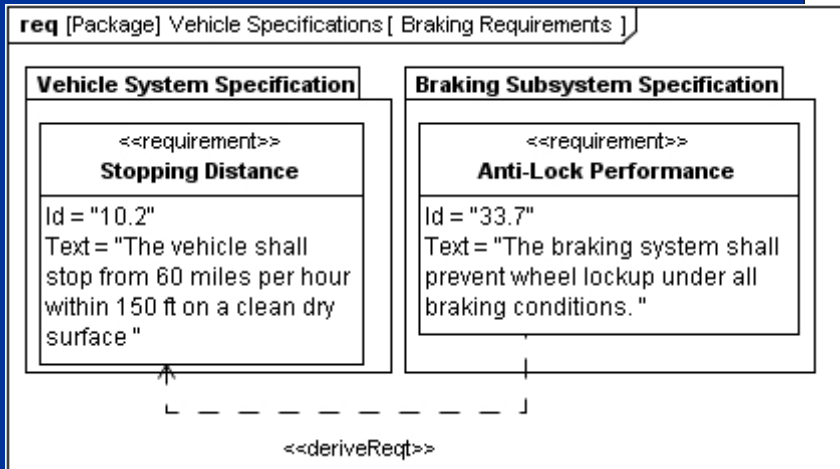
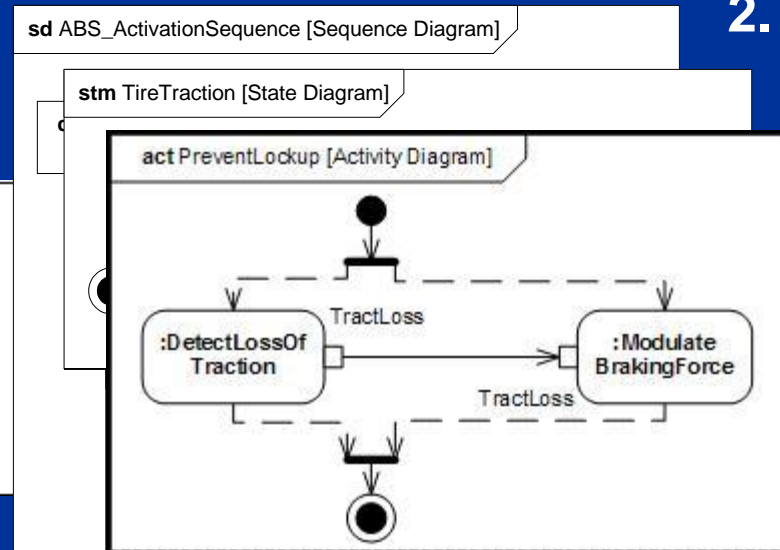


# 4 Pillars of SysML – ABS Example

## 1. Structure



## 2. Behavior

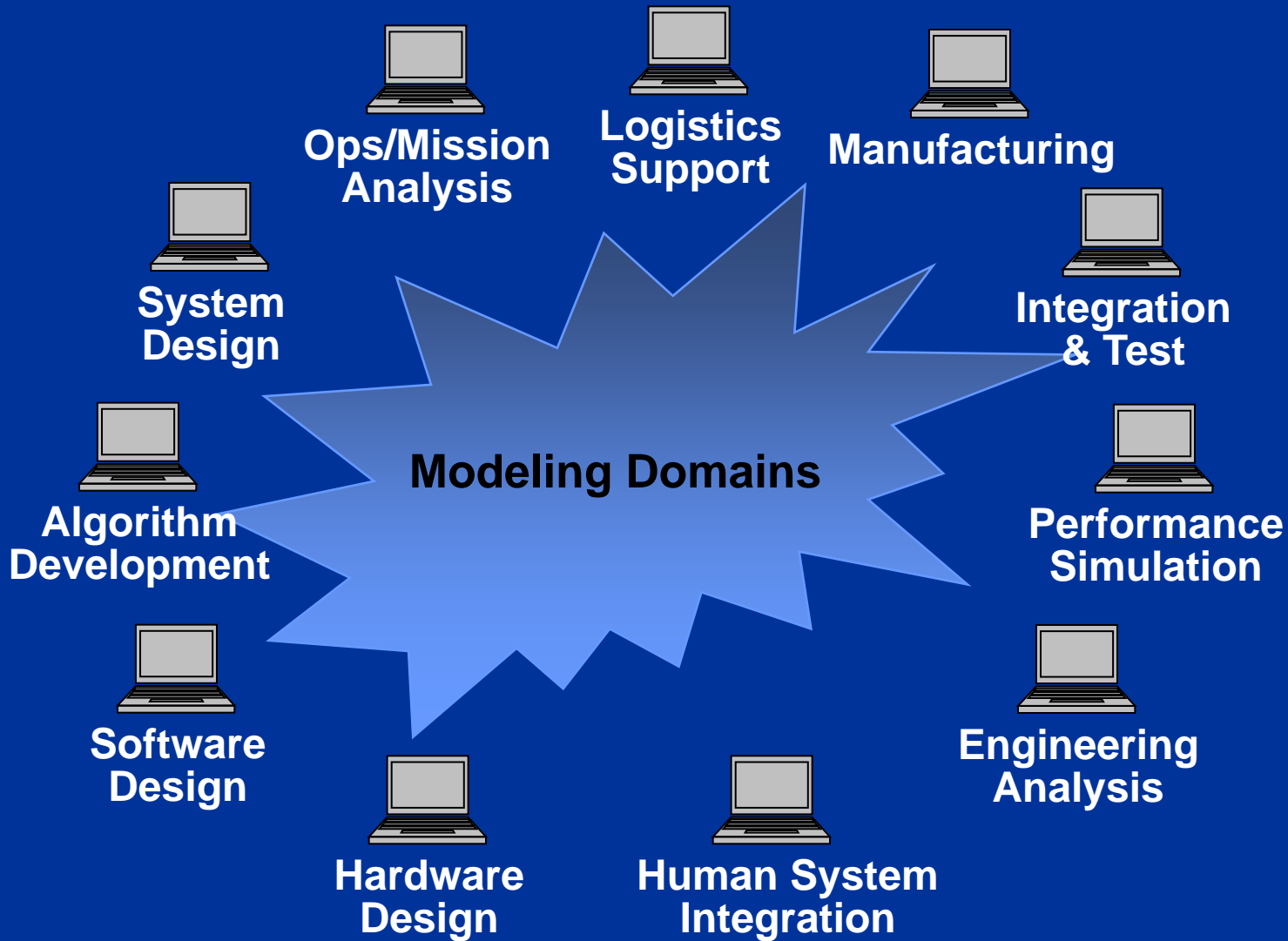


## 3. Requirements

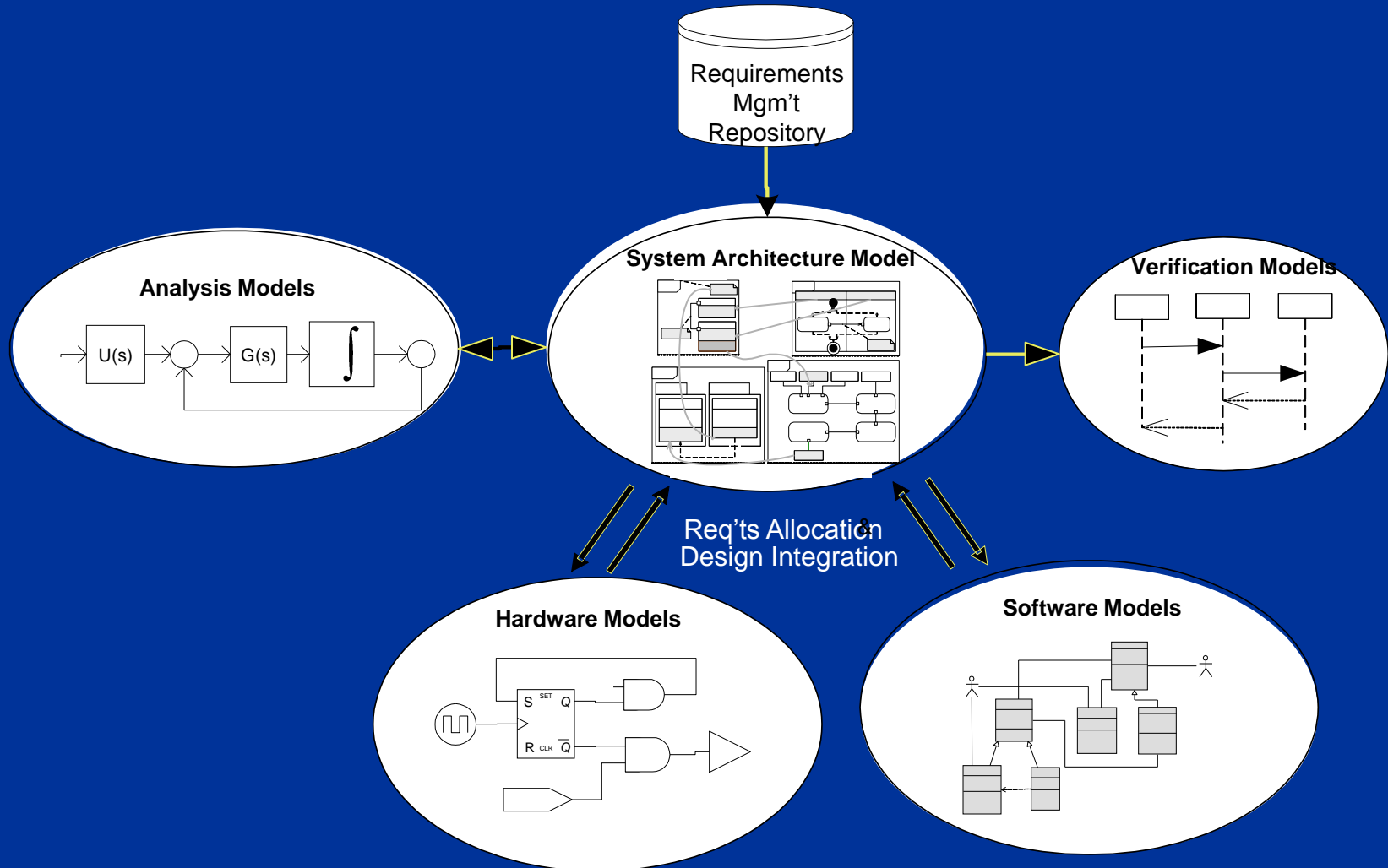
## 4. Parametrics

# **System Model as an Integration Framework**

# MBSE Must Integrate across Modeling Domains



# System Architecture Model Provides an Integration Framework

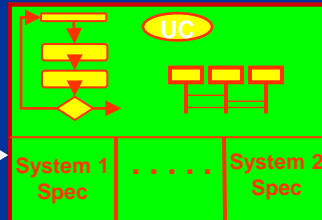


# Using the System Architecture Model to Flowdown Requirements

## System-of-System Level

- 1st Level Of Decompositions
- How Our System Contributes to the Overall Mission

Mission Concept of Operations



Trade Studies, Simulation, Specification Reviews, etc.

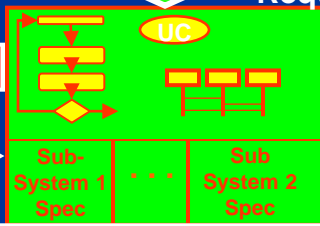
## System Level

- Derives Subsystems
- Allocates Requirements

Subsystems



A-Spec



Behavior, Structure & Requirements

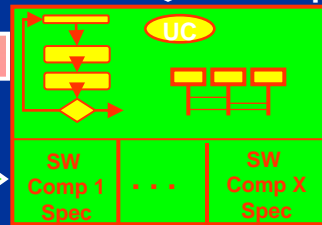
Trade Studies, Simulation, Specification Reviews, etc.

## Element Level

- Derives Hardware and Software Components
- Allocates Requirements to Components



B-Spec

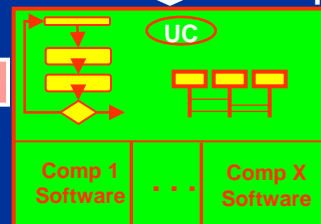


Behavior, Structure & Requirements

Trade Studies, Simulation, Specification Reviews, etc.

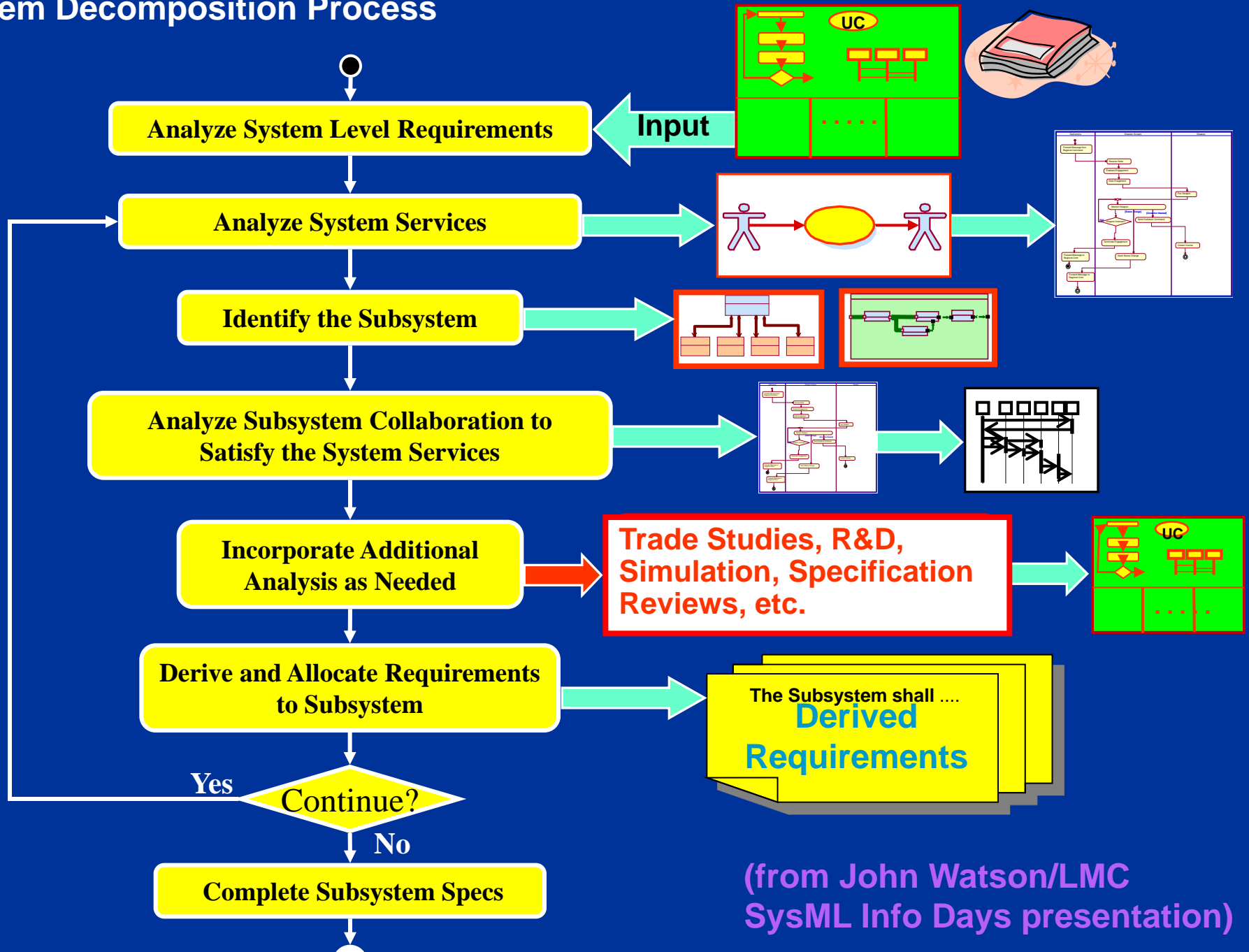
## Component Design & Implementation Level

(from John Watson/LMC SysML Info Days presentation)



Behavior, Structure & Requirements

# System Decomposition Process



(from John Watson/LMC SysML Info Days presentation)

# Integrating SysML with Simulation GIT Project

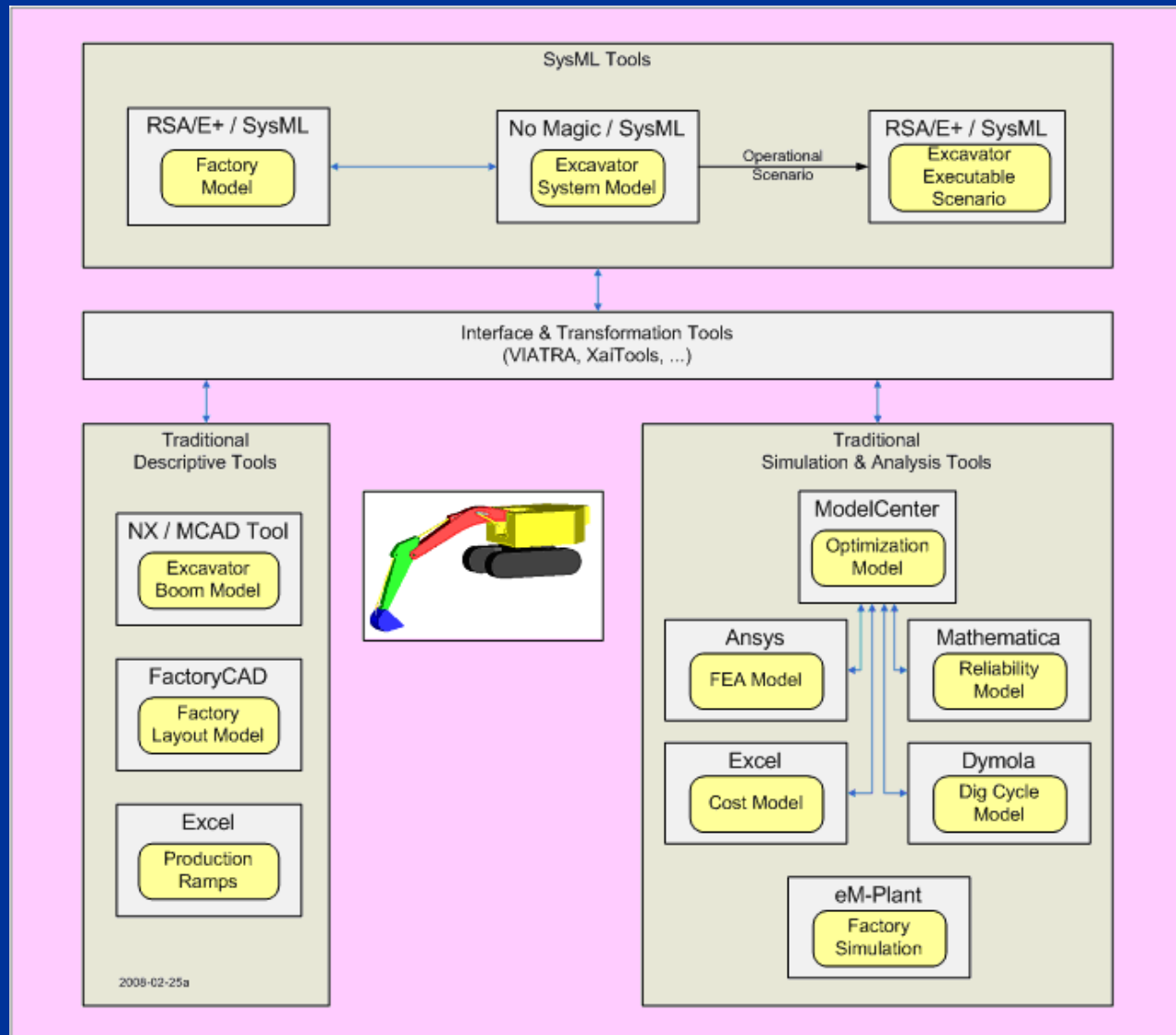
Modelica  
Lexical Representation  
(auto-generated from SysML)

```
package ExcavatorExample
...
class ExcavatorDigCycle
  Modelica.Mechanics.MultiBody.World world;
  ExcavatorExample.Components.Hydraulics hydraulics(redeclare
  ExcavatorModel.SubSystems.DigCycleSeq command(startTime=0.1)
  ExcavatorModel.SubSystems.MechanicsBody body(swing_phi_start
  ExcavatorExample.Interfaces.Nodes.TransNode2 node;
equation
  connect(hydraulics.boomCylBaseL, body.cylBoomLeftBase);
  connect(hydraulics.boomCylRodR, body.cylBoomRightRod);
  connect(hydraulics.boomCylRodL, body.cylBoomLeftRod);
  connect(hydraulics.armCylRod, body.cylArmRod);
  connect(hydraulics.armCylBase, body.cylArmBase);
  connect(hydraulics.bucketCylRod, body.cylBucketRod);
  connect(hydraulics.bucketCylBase, body.cylBucketBase);
  connect(hydraulics.commandSignal, command.commandSignal);
  connect(world.frame_b, body.baseFrame);
  connect(hydraulics.swingFlange, body.swingFlange);
  connect(hydraulics.boomCylBaseR, node.a);
  connect(node.b, body.cylBoomRightBase);
end ExcavatorDigCycle;
end ExcavatorExample;
```

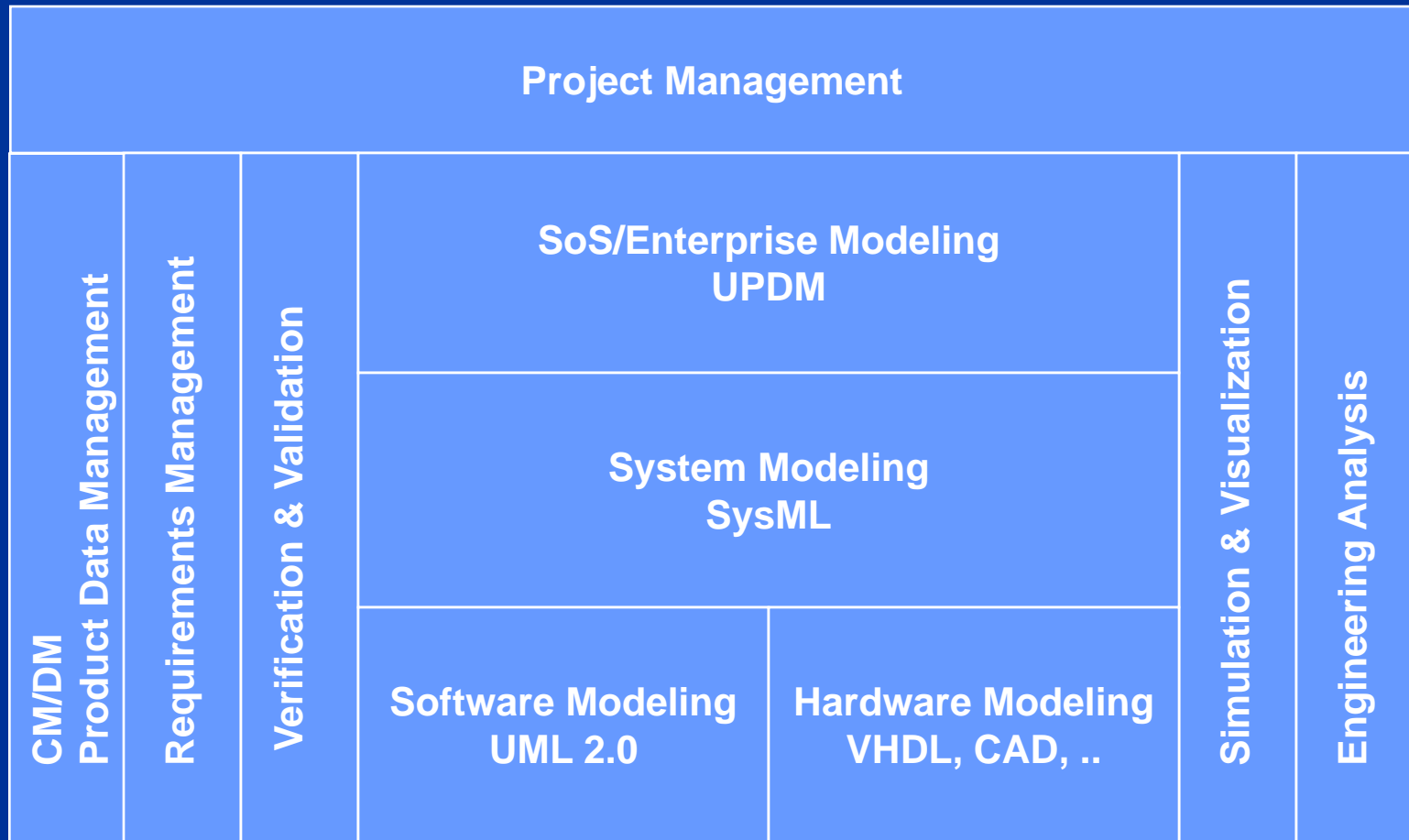
[Johnson, 2008 - Masters Thesis]

# Georgia Tech Research Project

## Integrating System Design Model with Simulation & Analysis Models



# Typical Integrated Tool Environment



# **SysML Status**

# OMG SysML™ Status

## ■ Specification

- OMG Beta Specification in May '06
- Available Specification v1.0 in Sept '07
- Available Specification v1.1 in Nov '08
- Revision task force for v1.2 in process

## ■ Adoption

- Multiple vendor implementations available
- Increasing number of early adopters across industry
- Being introduced into academia
- Books available (4)
- SysML Certification being planned
- DISR Emerging Standard (March 26, 2009)

- Information can be found on the **OMG SysML Website** at <http://www.omgSysml.org/>

# OMG SysML™ Status (cont.)

- **On-going Efforts**

- SysML/AP233 Integration
- SysML/Modelica WG
- Model interchange WG

- **Leveraging SysML in other OMG Specifications**

- UPDM, MARTE

- **University Courses**

- Fachhochschule Vorarlberg
- George Mason University
- Georgia Institute of Technology
- University of Arizona
- University of California at San Diego Extension
- Others ...

# Observations and Summary

# MBSE Observations

- **Transition from document-centric to model-centric is a cultural change**
- **Well defined MBSE method is essential**
- **Multiple tool vendors providing a range of price point, capability, and standards conformance**
- **MBSE training should include language, method, and tools**
- **Employ pilots to validate your MBSE approach**
- **Scope model based on program objectives and constraints**
- ***A lot has been learned, but much more remains***

# Summary

- **MBSE is a key practice to advance complex systems development**
- **Standards such as SysML are critical enablers of MBSE**
- **Multiple tool vendors implementing the standard**
- **System architecture model and standards based approach facilitate Integration across modeling domains**
- **Growing interest and application of MBSE**
- **INCOSE MBSE helping to advance and promote MBSE**