



# **SLIM for Model-Based Systems Engineering**

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**Manas Bajaj, PhD**

Chief Systems Officer  
[manas.bajaj@intercax.com](mailto:manas.bajaj@intercax.com)  
[www.InterCAX.com](http://www.InterCAX.com)


# About InterCAX

- Small business based in Atlanta, spin-off from Georgia Tech
- Background in standards-based modeling and simulation technology – SysML, MBSE, CAD, CAE, PLM
- First-in-market and leading provider of full-featured SysML parametric analysis software – ParaMagic® (for MagicDraw), Melody™ (Rhapsody), ParaSolver™ (Artisan Studio), and Solvea™ (Enterprise Architect)
- Active contributor to the development of
  - OMG SysML International Standard
  - ISO 10303-210 (AP210) Standard and related standards
  - OMG Certified Systems Modeling Professional Certification (OCSMP) program
  - Model-based Systems Engineering technology and practice

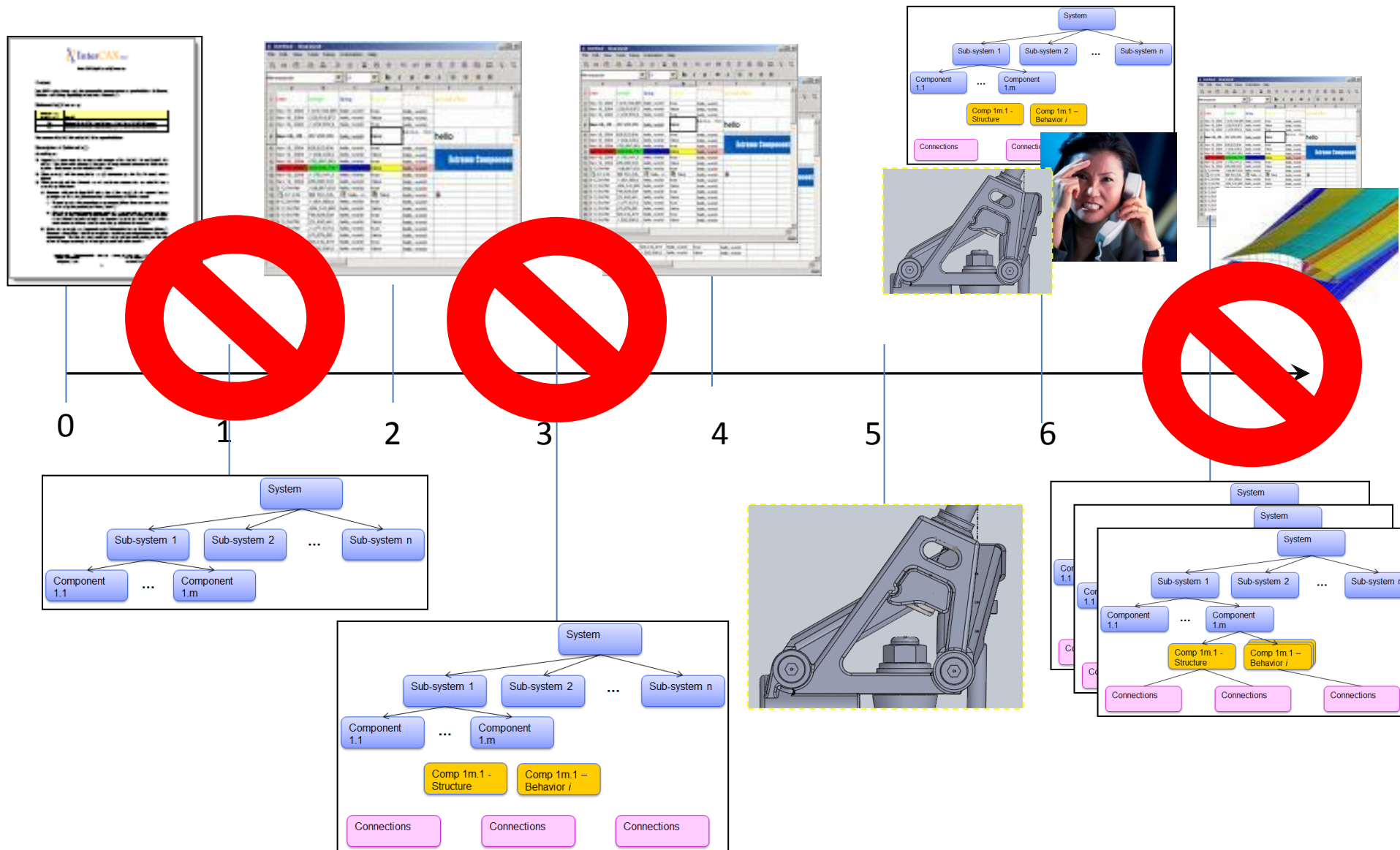
# About InterCAX (cont.)

- Customers in aerospace, defense, energy, electronics, automotive, biomedical, supply chain, telecom, and other sectors
- Business Focus
  - Software products
  - Services
    - SysML / MBSE training (2000+ participants since 2008)
    - Custom SysML/MBSE applications
    - Hands-on SysML/MBSE consultancy

# Contents

- Motivation 
- What is SLIM?
  - Conceptual Architecture
  - Use Cases
- SLIM – Bridging MBSE and PLM
- SLIM
  - NASA SBIR Phase 1 Project
  - SLIM Apps
- SLIM – Current capabilities and tools
- SLIM – Applications

# A week in the life of a system engineer



# Challenge

- **Identification**

- System, sub-system, interfaces (SysML, CAD, Databases,...)
- Parametric relations between system variables
- Behavior models (Procedural, Discrete-event, Cont. dynamics,...)
- Traceability to requirements (CRADLE, DOORS, PLM systems,...)

- **Integration**

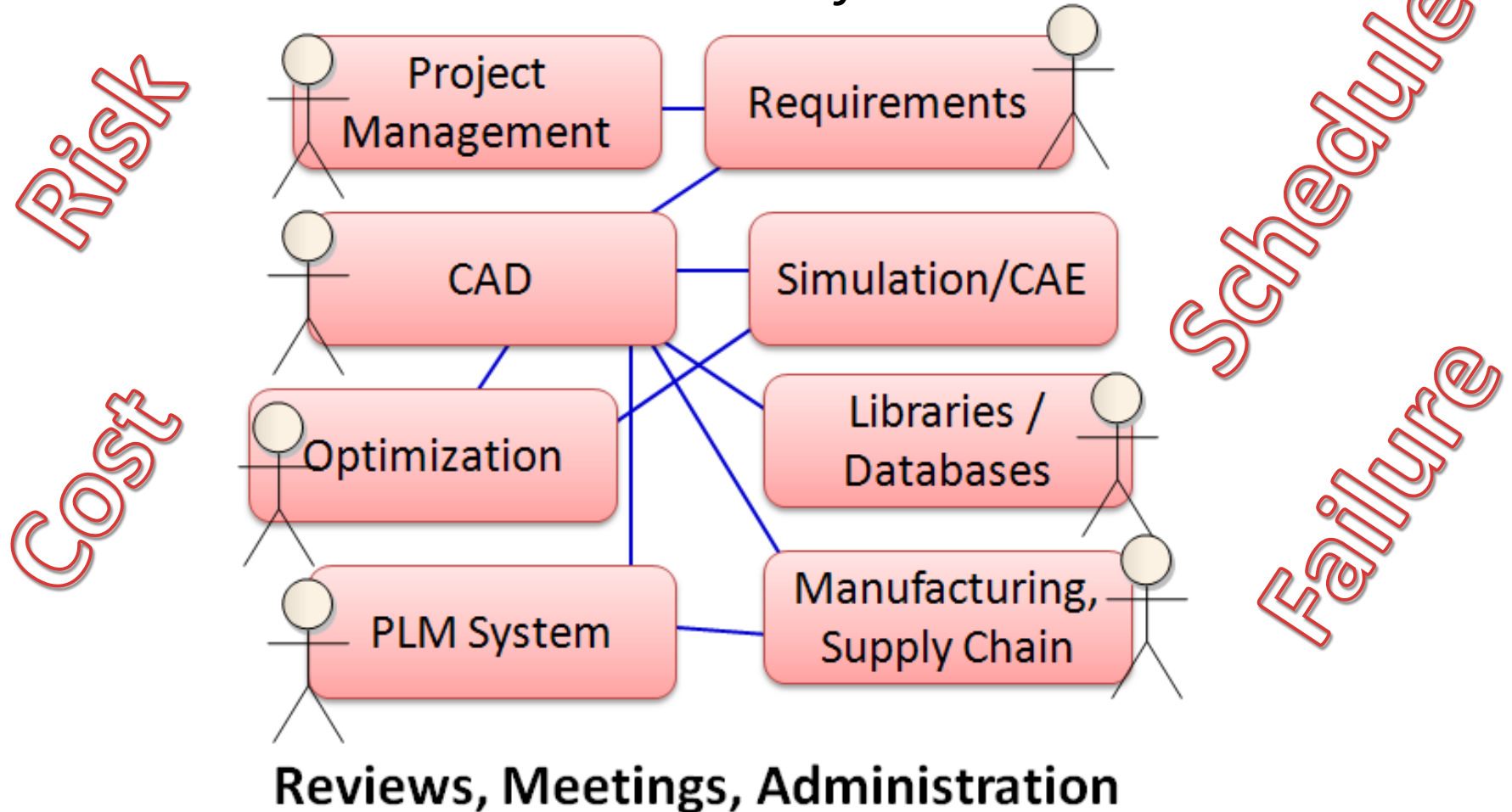
- Vertical (sys decomposition) and Horizontal (domains/aspects)
- Different types (fidelity, abstraction, formalism) of models from different tools collectively define the overall system

- **Continuity**

- Transition from conceptual to detailed design phase
- Versions and configuration of models and generated documents
- Systems engineering design and verification workflows
- Tracing design decisions to analysis results

# Challenge

*Point-to-Point Ad-Hoc Information Flows*

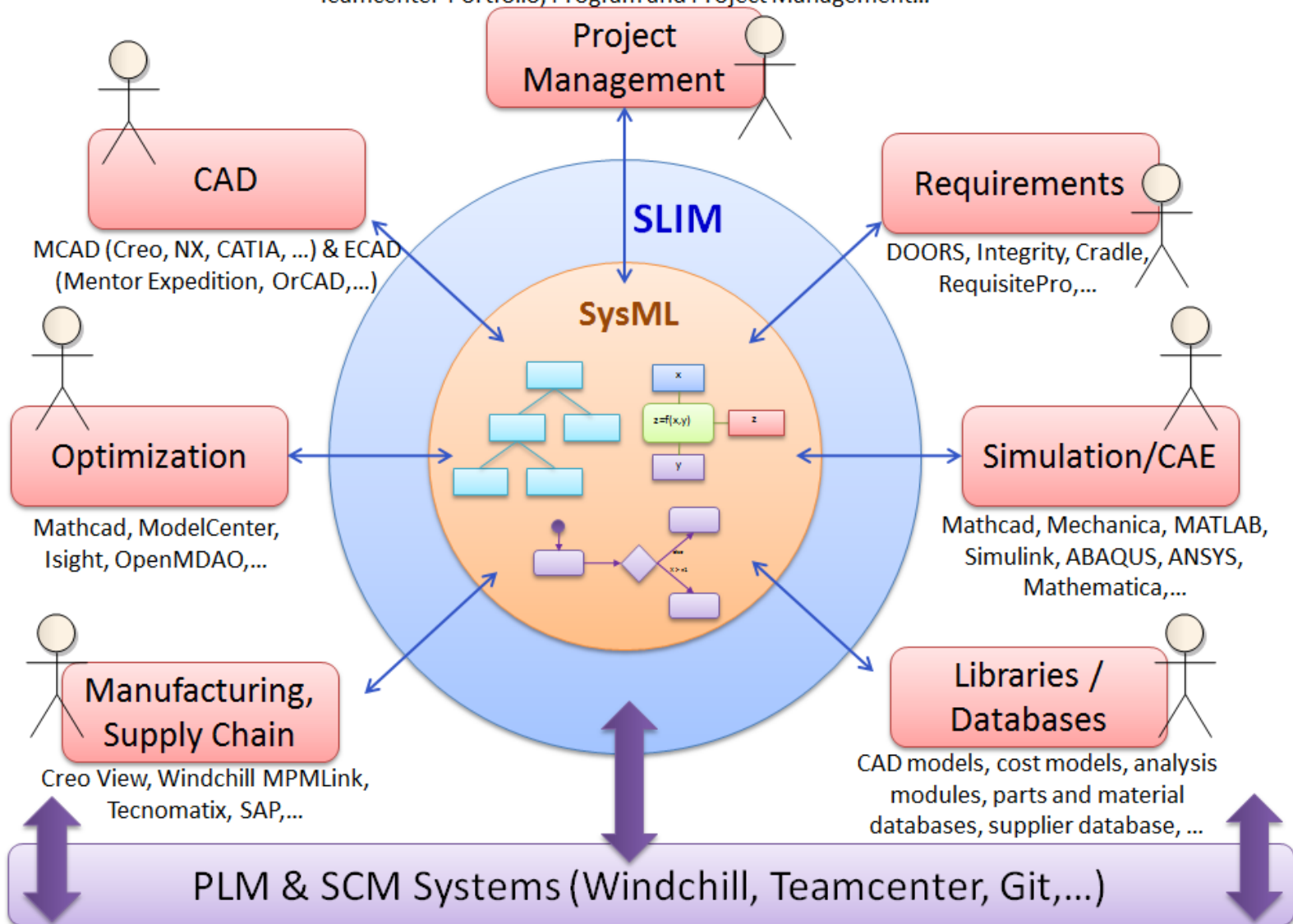


Use of models in systems engineering **IS NOT** model-based systems engineering (MBSE)

# System Lifecycle Management (SLIM)

## *Enabling Model-Based Systems Engineering*

Primavera, MS Project, Windchill ProjectLink and PPMLink,  
Teamcenter Portfolio, Program and Project Management...

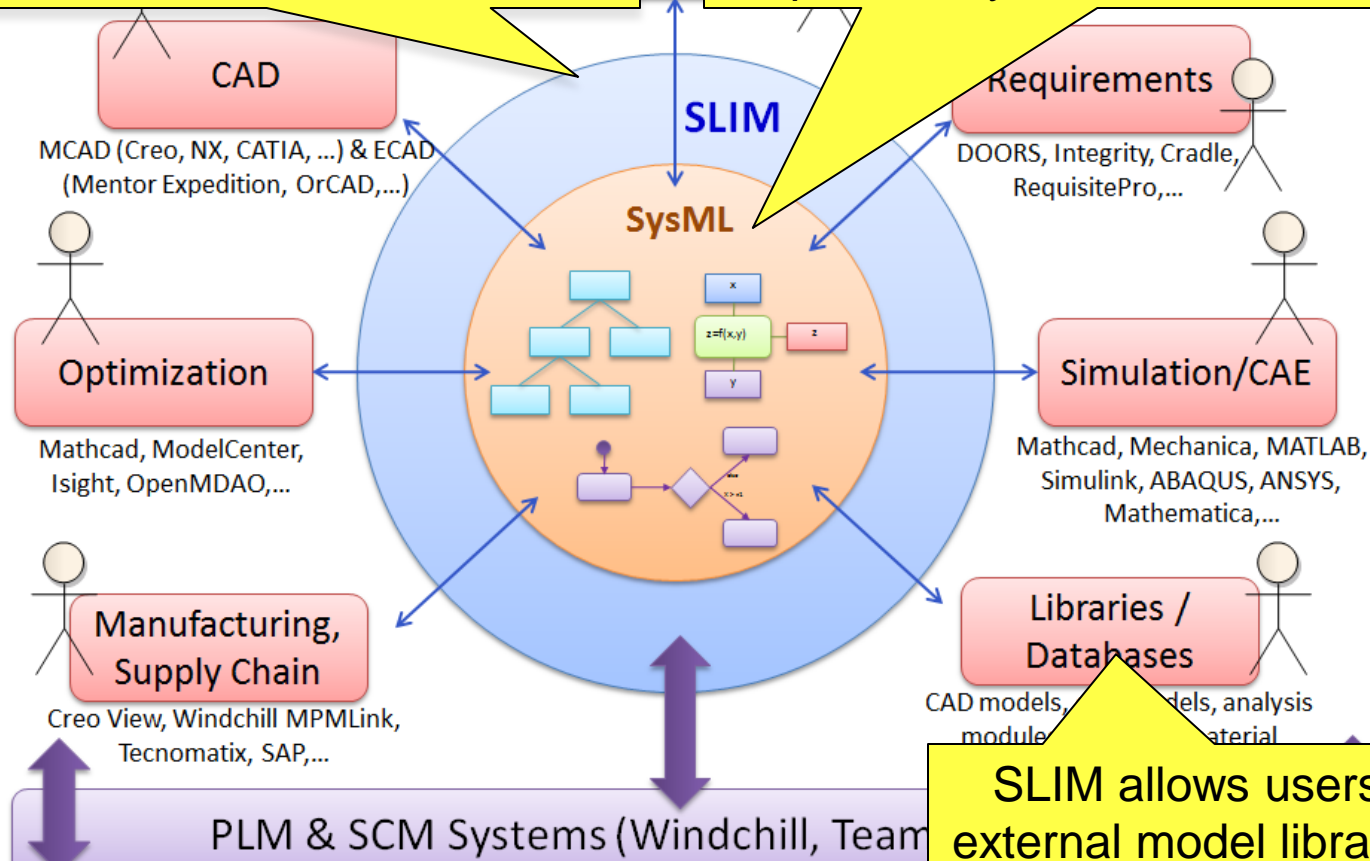




# SLIM - Conceptual Architecture

SLIM is deployed in the SysML environment. It provides tools to federate (visualize, connect, execute) domain-specific models from the SysML environment.

System engineers work directly in their SysML environment - *MagicDraw, Rhapsody, Artisan Studio, Enterprise Architect*). SysML model is a conceptual map of the system.

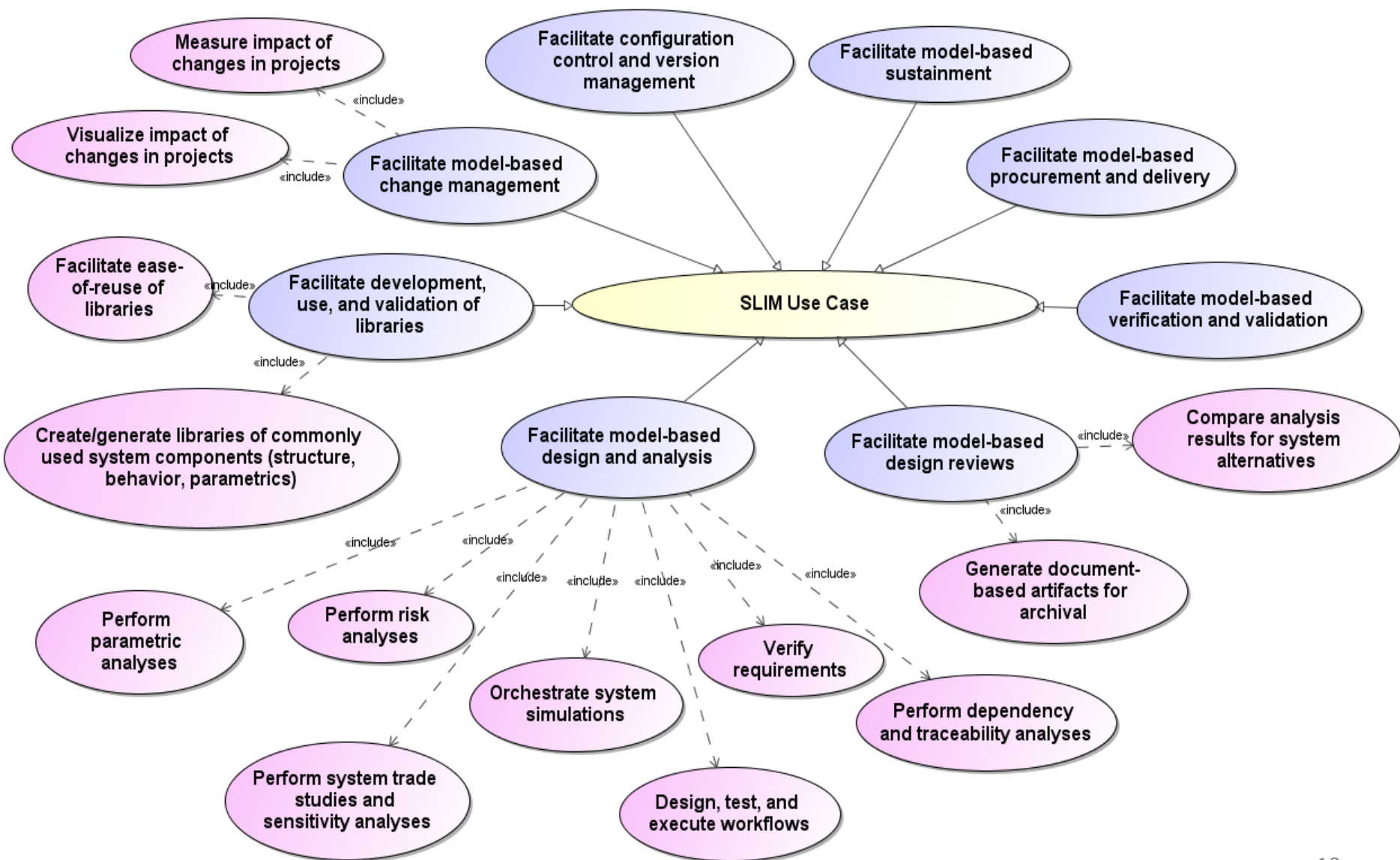


SLIM uses enterprise PLM and SCM systems for configuration control


SLIM allows users to wrap external model libraries (CAD, CAE, MATLAB,..) as plug-and-play SysML objects.<sup>9</sup>

# SLIM – Systems Engineering Use Cases

uc [Package] Use Cases [ SLIM Use Cases ]



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- SLIM – Current capabilities and tools
- SLIM - Applications

# Product Lifecycle Management

- Idea -> Design -> Manufacturing -> Service -> Disposal

The screenshot displays the Windchill software interface for managing product data. The main window shows the 'Part - SYSTEM101, System, A.6 (Design)' with various tabs like Details, Structure, Related Objects, Changes, History, Where Used, Traceability, and Relationship Explorer. The 'Structure' tab is active, showing a hierarchical tree of components. A red arrow points from the 'Product structure (BOM)' label to the tree. A green arrow points from the 'Related artifacts (CAD, doc, xls, ...)' label to the tree. A purple arrow points from the 'Versioning' label to the 'Attributes' tab. A blue arrow points from the 'Configuration Control' label to the 'Status' field. An orange box with the text '...and much more' is located in the top right corner. The 'Attributes' tab shows 'CAD Document Attributes' with fields for Number, Name, Revision, State, Modified By, Last Modified, and Status. The 'Status' field is set to 'Checked in'.

**Product structure (BOM)**

**Related artifacts (CAD, doc, xls, ...)**

**Versioning**

**Configuration Control**

**...and much more**

**Windchill**

# Product Lifecycle Management

- Idea -> Design -> Manufacturing -> Service -> Disposal

The screenshot displays the Siemens Teamcenter 9 interface. The left sidebar contains navigation options: My Worklist, My Projects, My Links, My Saved Searches, My View/Markup, Open Items, History, Lifecycle Viewer, Structure Manager, Systems Engineering, Organization, Project, Access Manager, and Workflow Designer. The main workspace is divided into two panes. The left pane shows a hierarchical tree structure under 'My NX\_Models', including '000114-Simple Shape' and its sub-items '000114/A;1-Simple Shape', '000114/B;1-Simple Shape', and '000114/C;1-Simple Shape'. The right pane shows a 3D model of a mechanical part. A red arrow points from the 'Product structure (BOM)' label to the tree structure. A green arrow points from the 'Related artifacts (CAD, doc, xls, ...)' label to the '000114/A;1-Simple Shape' item. A purple arrow points from the 'Versioning' label to the '000114/C;1-Simple Shape' item. An orange arrow points from the 'Configuration Control' label to the table at the bottom. The table lists the configuration details for the '000114-Simple Shape'.

**Product structure (BOM)**

**Related artifacts (CAD, doc, xls, ...)**

**Versioning**

**Configuration Control**

Object	Type	Relation	Owner	Group ID	Last Modified Date	Checked-Out	Release Status
000114	Item Master	Item Masters	Manas Baja	Engineering	29-Mar-2012 14:39		
000114/A;1-Simple Shape	ItemRevision	Revisions	Manas Baja	Engineering	29-Mar-2012 14:54		Released
000114/B;1-Simple Shape	ItemRevision	Revisions	Manas Baja	dba	29-Mar-2012 15:04		
000114/C;1-Simple Shape	ItemRevision	Revisions	Manas Baja	dba	29-Mar-2012 15:07		

Teamcenter

# What has PLM go to do with MBSE?

- Who is responsible for different sub-systems and their functions?
- What specific sub-systems were allocated to CAD engineers?
- What specific version of the system model was used during this allocation?
- What specific versions of the CAD models were connected to the system model?
- What specific parameters of the sub-system X were connected to the CAD model parameters and how?
- What specific system measures-of-effectiveness was analyzed by the system engineer? What analysis models were used?
- What specific versions of the SysML parameteric model, and related domain-specific analysis models were used?
- What were the results of this analysis?
- What design decisions were taken following this analysis and by whom?

# NASA SBIR Project – Phase 1

## *SLIM for Agile Mission Lifecycle Management*

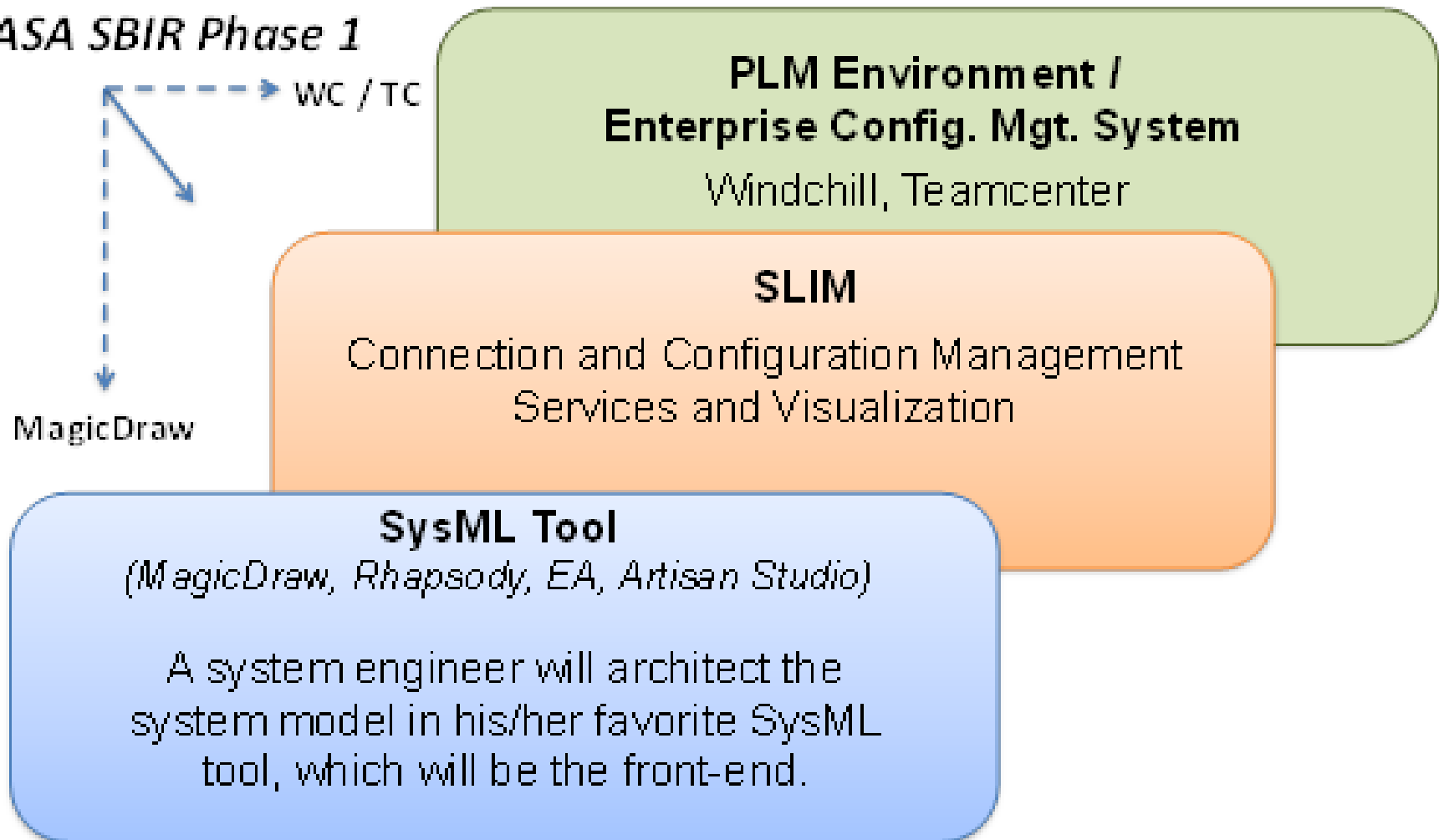
### Technical Objectives

- *Establish fine-grained, information-rich connections between the SysML-based system model and variety of other artifacts, such as CAD, CAE, Excel, MATLAB, Mathematica models, and Word documents to name a few, using integration patterns that facilitate different system engineering workflows.*
- *Demonstrate execution of patterns that are fundamental to realizing system engineering design and verification workflows, such as synchronizing values between SysML models and connected artifacts in PLM systems, and wrapping executable models (MATLAB/Simulink, Mathematica,...) managed in PLM systems as SysML constructs and executing them in the context of SysML model execution*
- *Manage different versions and configurations of (a) the SysML-based system model, (b) the connected artifacts (e.g. CAD/CAE models and Word/Excel docs), and (c) the fine-grained relationships between the system model and artifacts, in an enterprise-class PLM environment such as Windchill or Teamcenter.*

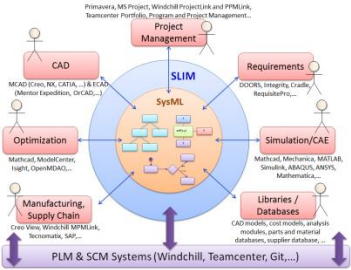
# NASA SBIR Project – Phase 1

## *SLIM for Agile Mission Lifecycle Management*

*NASA SBIR Phase 1*



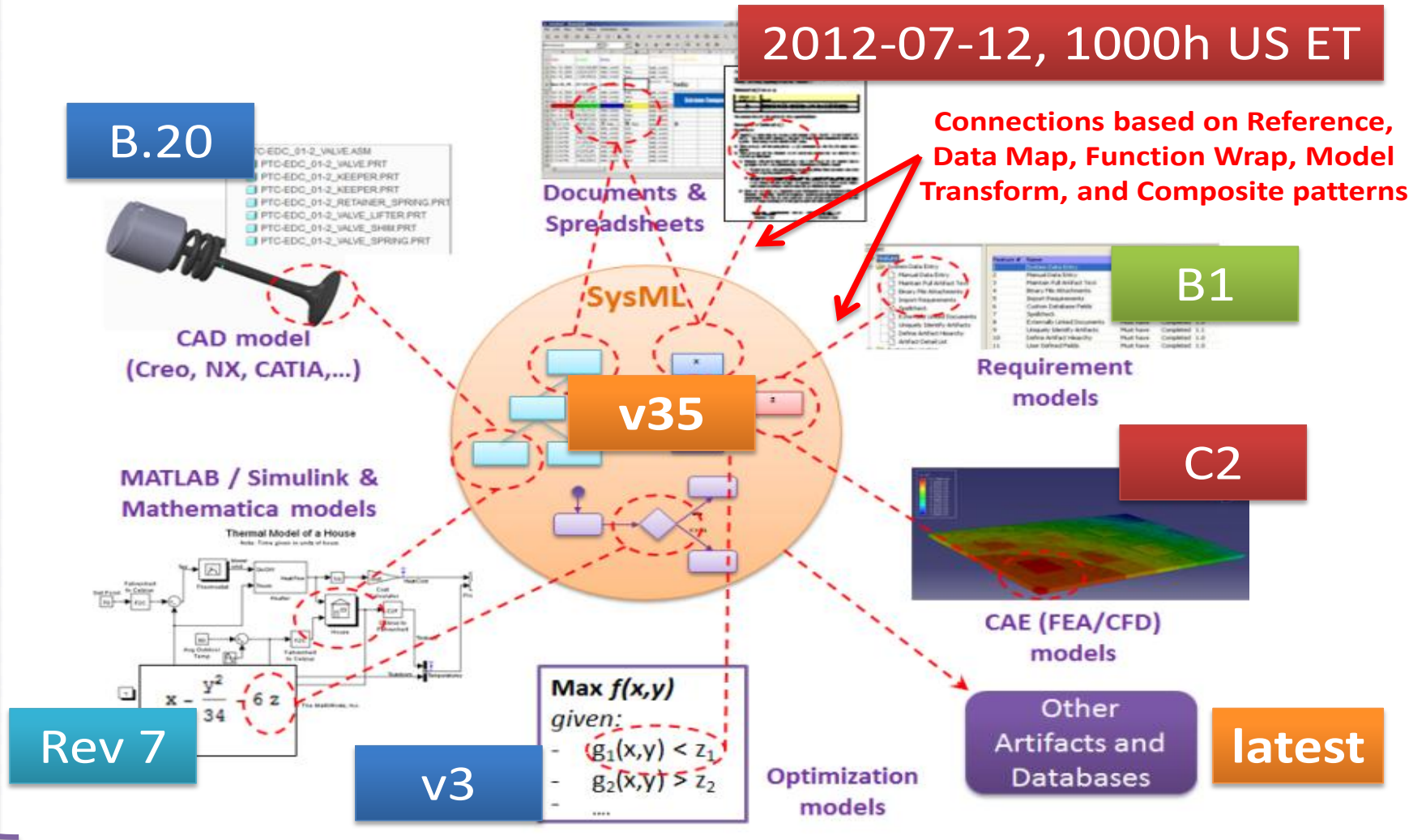




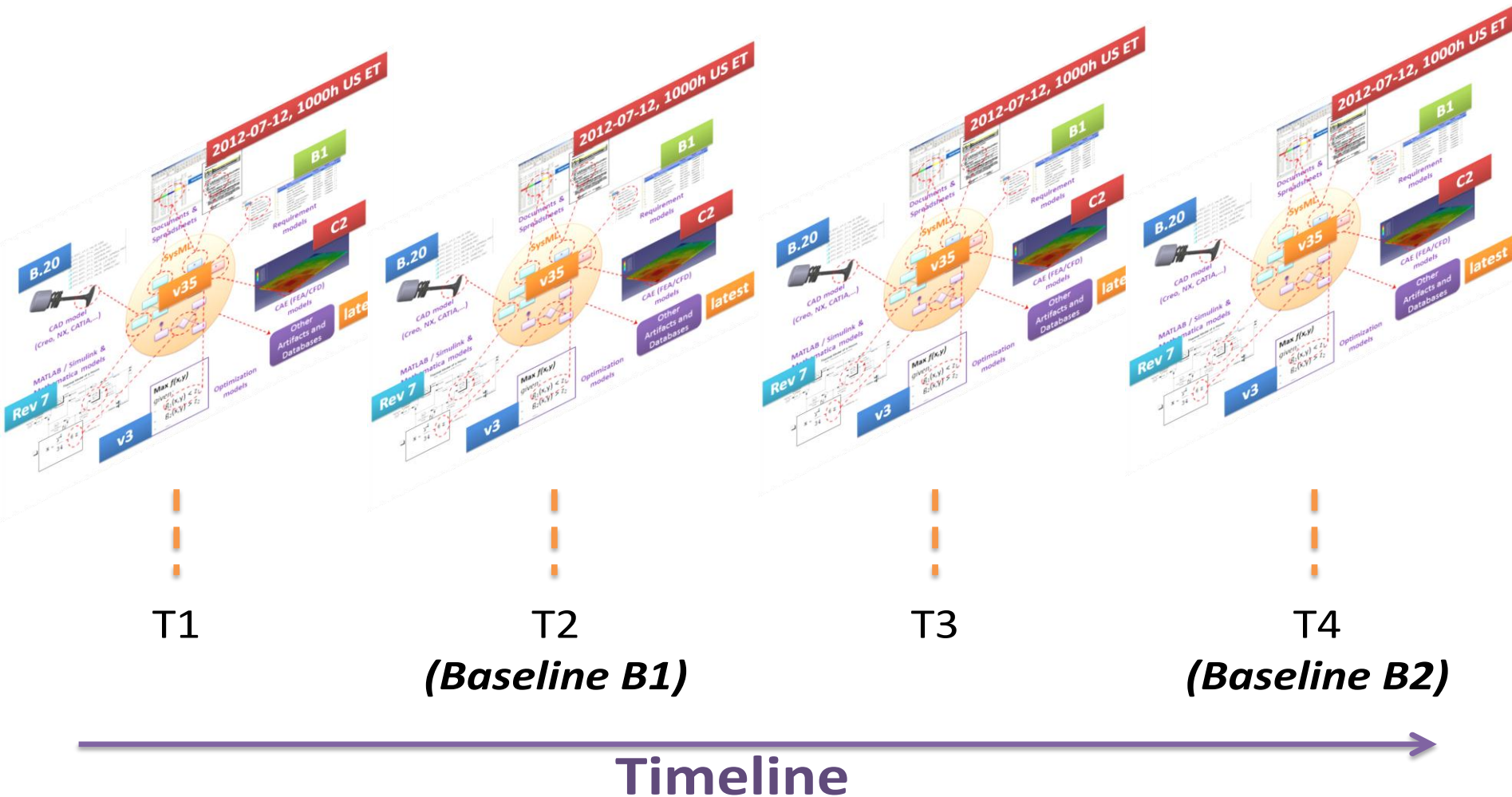
# Total System Model

## Created and managed using SLIM

TOTAL SYSTEM MODEL (TSM)



# Total System Model History



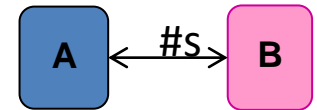
# SLIM's Connection Patterns

- Reference Connection
- Data Map Connection
- Function Wrap Connection
- Model Transform Connection
- Composite Connection

# SLIM's Connection Patterns

- **Transfer Data between Independent Models (Data Map)**

- SysML-Excel, SysML-Databases

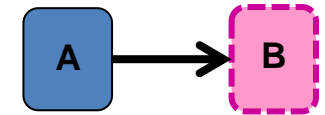


- **Wrap external functions/code (Function Wrap)**

- External function calls (SysML-MATLAB/Simulink/Java)

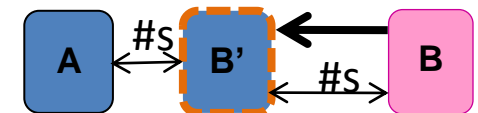
- **Transform Model from Tool A to Tool B (Model Transform)**

- SysML parametric solvers export equations to Mathematica, MATLAB, and OpenModelica
- Seed FEA models from CAD models
- Reverse engineering: Generate design models (SysML-based system models) from analytical models (Simulink models)



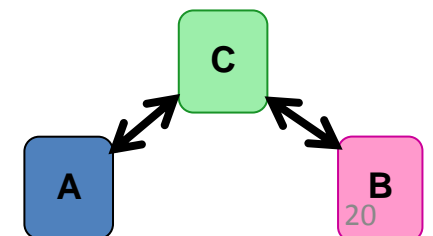
- **Mirror Model from Tool B in Tool A (Model Transform)**

- SysML - CAD, STK (bi-directional data flow)



- **More Complex Patterns (Composite)**

- Intermediate models and repositories



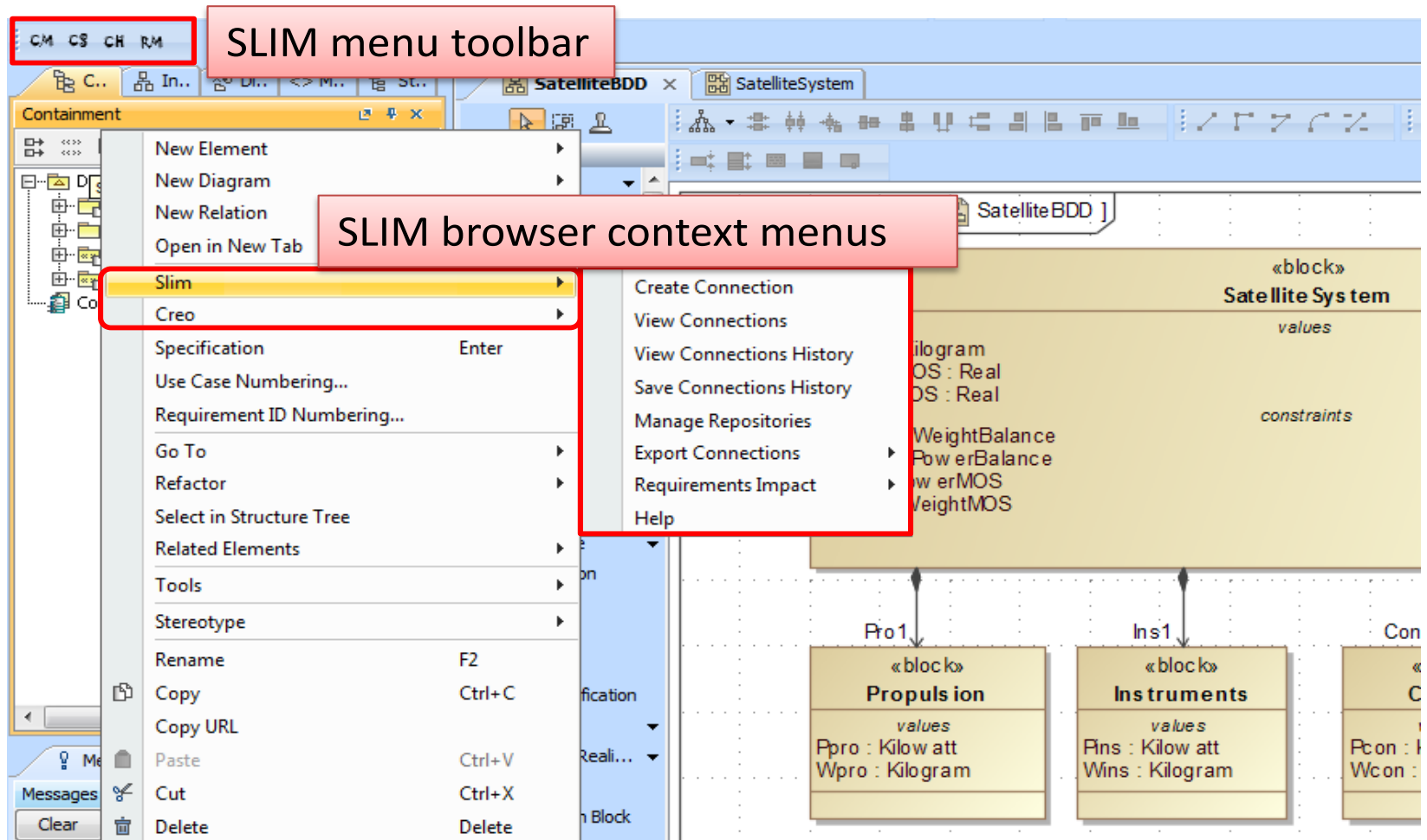
# SLIM capabilities

## (developed in SBIR Phase 1)

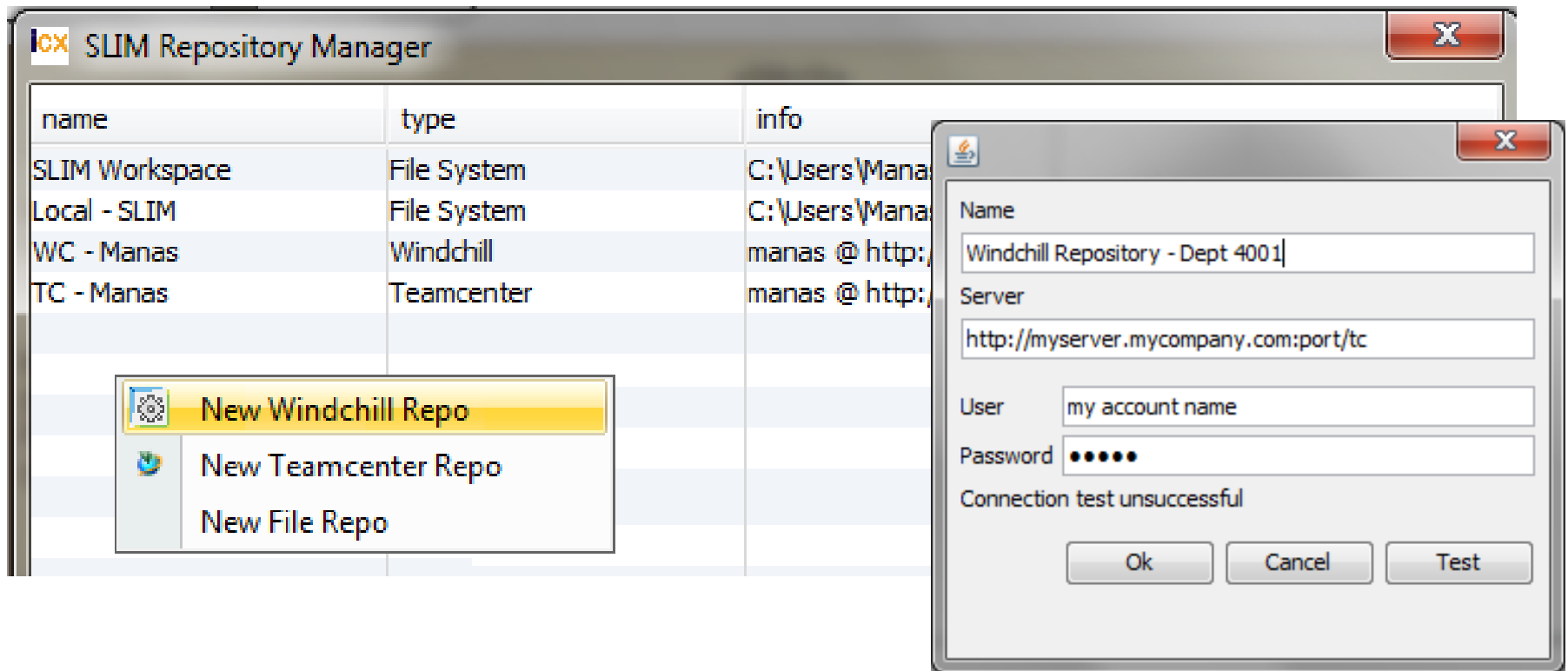
- SLIM Plugin for MagicDraw
- Repository Manager
- Connection Creator
- Connection Viewer
- History Viewer
- Requirement Impact Check

DEMO

# SLIM Plugin for MagicDraw



# Repository Manager



# Connection Creator

Active filtering of all columns based on connection library

Switch repositories

The screenshot shows the 'SLIM Connections Manager' window. It is divided into three main panes. The left pane, titled 'SysML Model', displays a hierarchical tree of model elements. The middle pane, titled 'Connection Type', contains radio buttons for 'Reference', 'Function Wrap', 'Data Map', 'Model Transform', and 'Composite'. The right pane, titled 'Repository', shows a tree of artifacts. Annotations include: a purple box at the top center pointing to the 'Connection Type' pane; a purple box at the top right for repository switching; a purple box on the right for the 'Structure View'; a purple box on the right for the 'Folder View'; a purple box on the right for the 'Baseline View'; a blue box at the bottom left for the 'SysML model (MagicDraw)'; a red box at the bottom center for the 'Connection function/type'; a purple box at the bottom right for the 'Artifact Repository (Windchill shown)'; and an orange box labeled 'Versions' pointing to a group of artifacts in the repository tree. At the bottom of the window are buttons for '< Back', 'Next >', and 'Cancel'.

SLIM Connections Manager

SysML Model

Connection Type

Repository

Manage Repositories  
Refresh Repository  
Local - SLIM  
SLIM Workspace  
TC - Manas  
WC - Manas

Structure View

Folder View

Baseline View

SysML model (MagicDraw)

Connection function/type

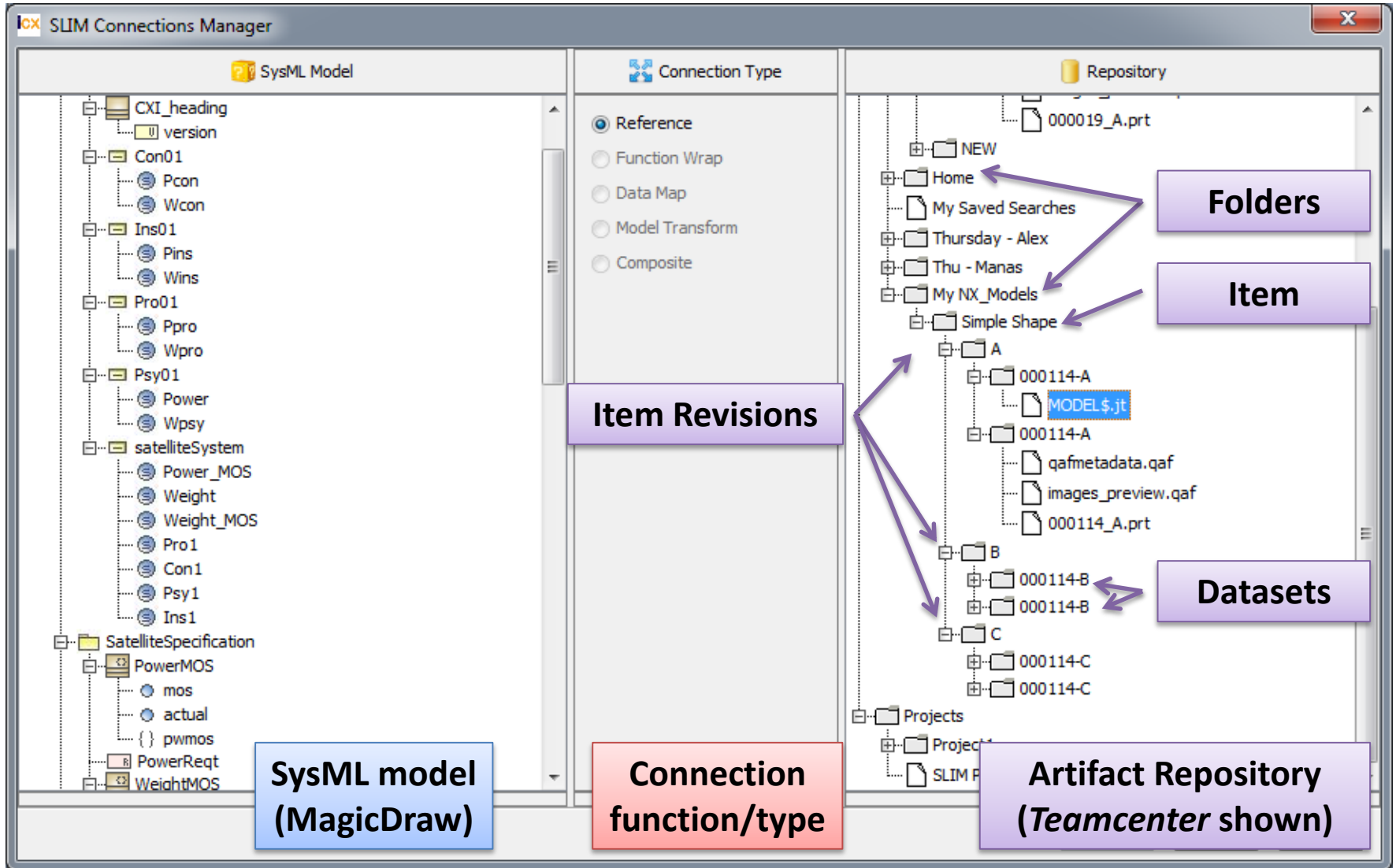
Artifact Repository (Windchill shown)

Versions

< Back Next > Cancel



# Connection Creator (Teamcenter Repo)



# Connection Creator - specs

## SysML Instance-Excel Data Map

**Specifications for Instance-Excel Data Map Connection**

**Left Panel (Tree View):**

- satelliteSystem
  - Con1
    - Con01
      - Pcon
      - Wcon
  - Ins1
    - Ins01
      - Pins
      - Wins
  - Power\_MOS
  - Pro1
    - Pro01
      - Ppro
      - Wpro
  - Psy1
    - Psy01
      - Power
      - Wpsy
  - Weight
  - Weight\_MOS

**Right Panel (Configuration):**

**Workbook/Worksheet**

☒ Default Workbook: LE\_Trade.xlsx

☒ Default Worksheet: Sheet1

**Cell Selection**

Cell Range:

Access Mode: ☐ Read ☐ Write ☒ None

Excel Preview: {}

Current Value: { 1500 }

# Connection Viewer

SLIM Connections Summary					
SysML Model	Conn ID	Conn Type	Repo Name	Repo Type	Artifact
Data					
<ul style="list-style-type: none"> <li>Satellite           <ul style="list-style-type: none"> <li>Instance_01               <ul style="list-style-type: none"> <li>Con01</li> <li>Ins01</li> <li>Pro01</li> <li>Psy01                   <ul style="list-style-type: none"> <li>Power                       <ul style="list-style-type: none"> <li>Wpsy                           <ul style="list-style-type: none"> <li>satelliteSystem                               <ul style="list-style-type: none"> <li>Con1</li> <li>Ins1</li> <li>Power_MOS                                   <ul style="list-style-type: none"> <li>Pro1</li> <li>Psy1</li> <li>Weight                                       <ul style="list-style-type: none"> <li>Weight_MOS</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> <li>SatelliteSpecification</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>connection6</li> <li>connection6</li> <li>connection6</li> <li>connection2</li> <li>connection1</li> <li>connection2</li> <li>connection2</li> <li>connection2</li> <li>connection2</li> </ul>	<ul style="list-style-type: none"> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>REF</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> <li>INSTANCE_SPECIFICATION_EXCEL_DATA_MAP</li> </ul>	<ul style="list-style-type: none"> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> <li>Windchill repo - Manas</li> </ul>	<ul style="list-style-type: none"> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> <li>windchill_repository</li> </ul>	<ul style="list-style-type: none"> <li>mission.xlsx (A.1)</li> <li>mission.xlsx (A.1)</li> <li>mission.xlsx (A.1)</li> <li>mission.xlsx (A.1) (Sheet1)</li> <li>Satellite (B.1)</li> <li>mission.xlsx (A.1)</li> <li>mission.xlsx (A.1)</li> <li>mission.xlsx (A.1)</li> <li>mission.xlsx (A.1)</li> </ul>

# History Viewer

SLIM Connections History - Satellite::PowerBalance::powerdemand					
Saved Connections	08/10/2012 12:05:47	08/10/2012 12:06:55	08/10/2012 12:37:48	08/10/2012 12:38:48	Current
connection7		annualcycle.m (A.1)			✗
connection8				Power System (B.1)	Power System (B.1)
*****					
Conn ID: connection7	Artifact	Version	Last Modified	Repo	Repo Type
Conn Type: CONSTRAINT_BLOCK_MAT	annualcycle.m	A.1	2012-07-18 16:00	Windchill repo - Manas	windchill_repository
Conn Func: FUNCTION_WRAP					
Conn Elem: powerdemand / Satellite::Po					

# Check for newer versions and baselines of connection models

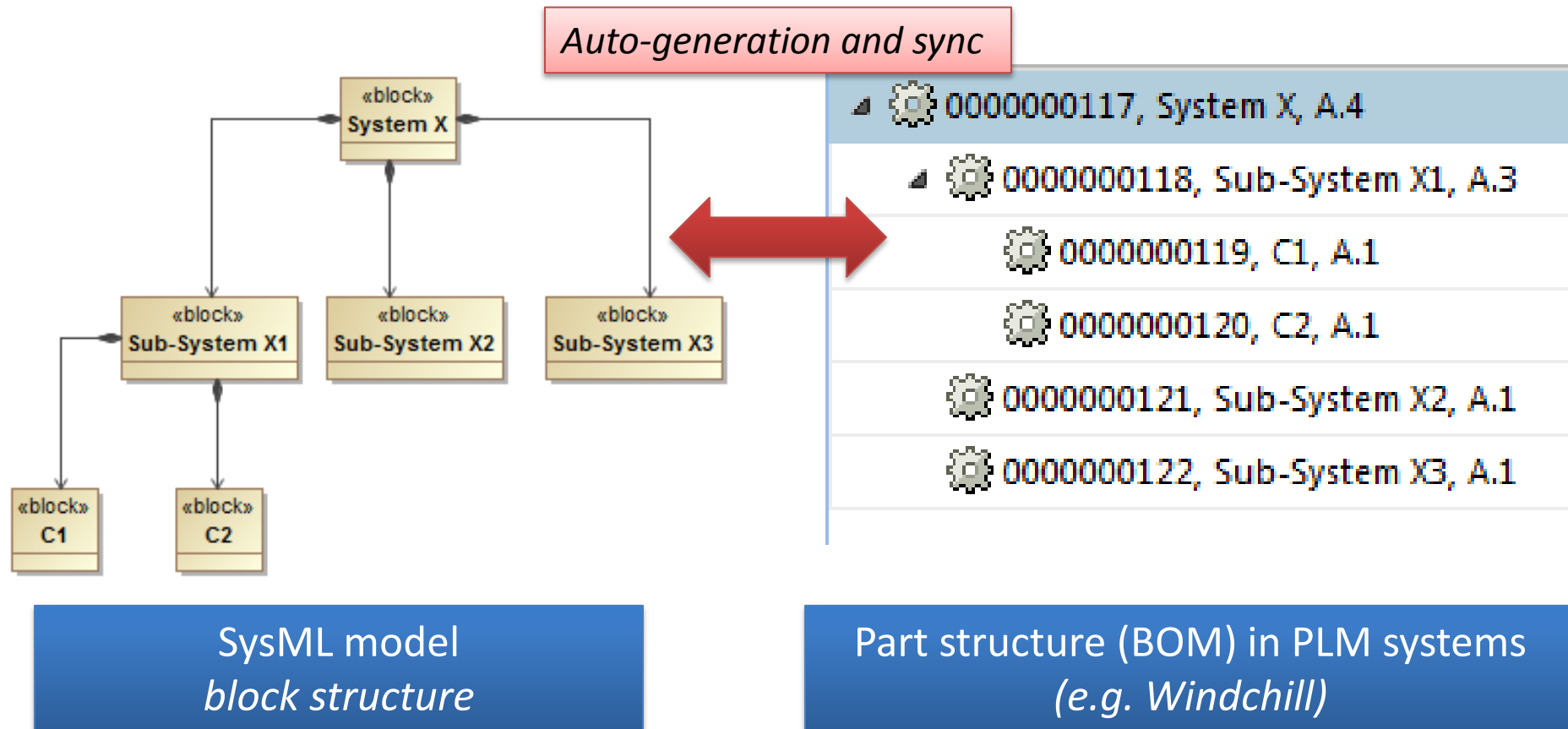
The screenshot shows the 'SLIM Connections Summary' window. On the left, a tree view shows the hierarchy: Data > Satellite > Instance\_01 > satelliteSystem. 'connection9' is selected, indicated by a red icon. A context menu is open over 'connection9', listing options: Refresh, Create Connection, Delete Connection, View Connections History, Save Connections History, Check New (highlighted), Artifacts Details..., and Test. The 'Check New' option has a submenu with 'Version' (highlighted), 'Revision', and 'Baseline'. Below the tree, a table lists connections:

Conn ID	Conn Type	Repo Name	Repo Type	Artifact
connection9	REF			.. Satellite (A.6)
connection2		INSTANCE_...	Windchill re...	windchill_re... mission.xlsx (A.1) (Sheet1)
Con1				
Ins1				
Power_MO:				
connection2		INSTANCE_...	Windchill re...	windchill_re... mission.xlsx (A.1)
Pro1				

At the bottom, a detailed view for 'connection9' is shown:

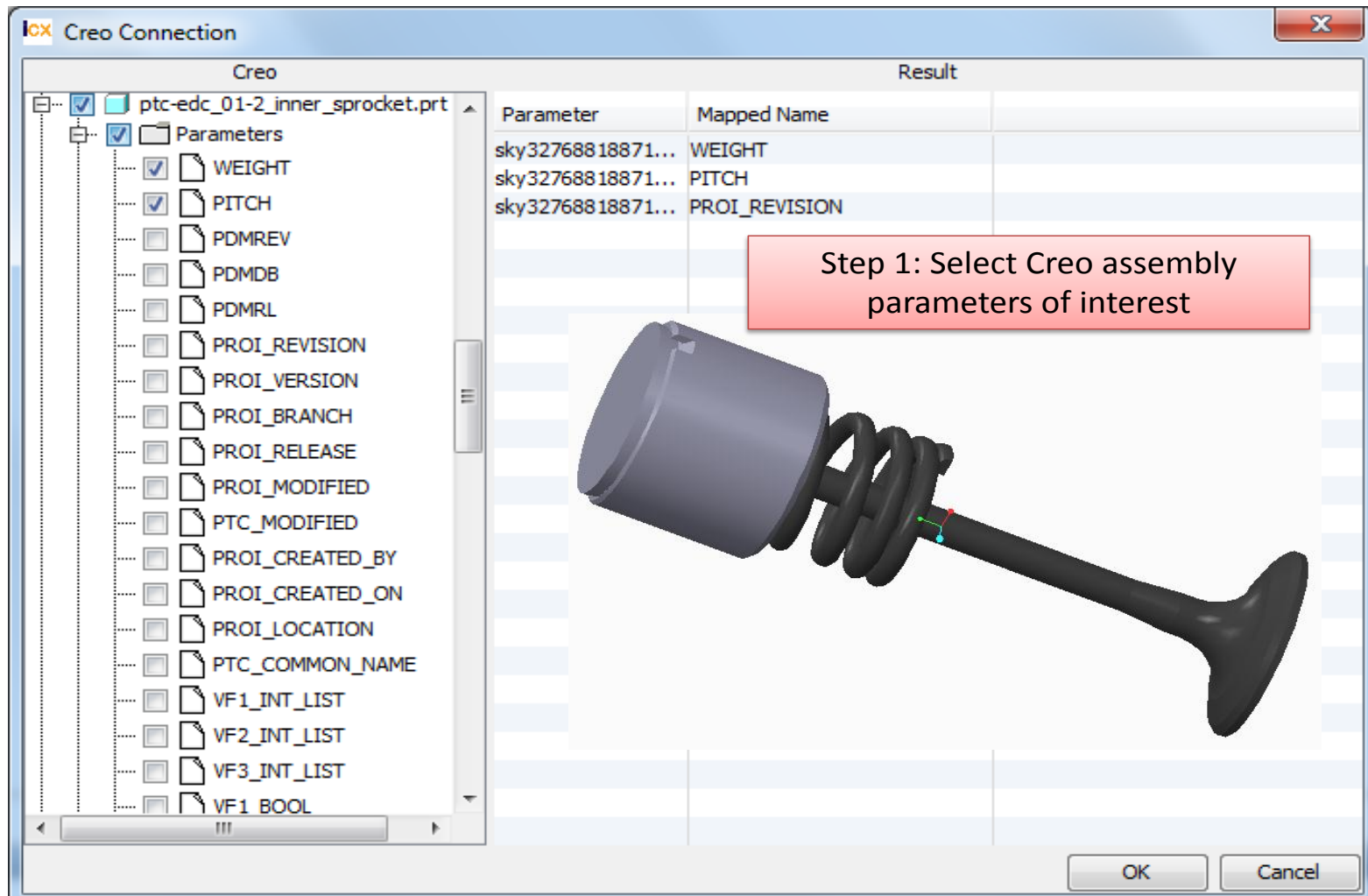
Conn ID: connection9	Artifact	Connected Version	Latest Version
Conn Type: REF	Satellite	! A.6	B.1
Conn Func: REF			
Conn Elem: satelliteSystem / Satellite::Ir			

# Generating PLM part structure from SysML block structure and vice versa



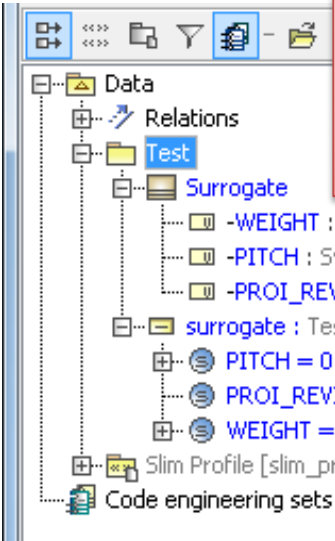
# Connection Creator – specs

## SysML Block/Instance-Creo Data Map



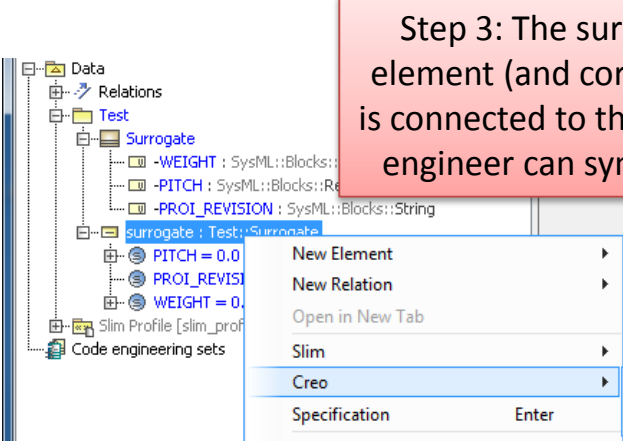
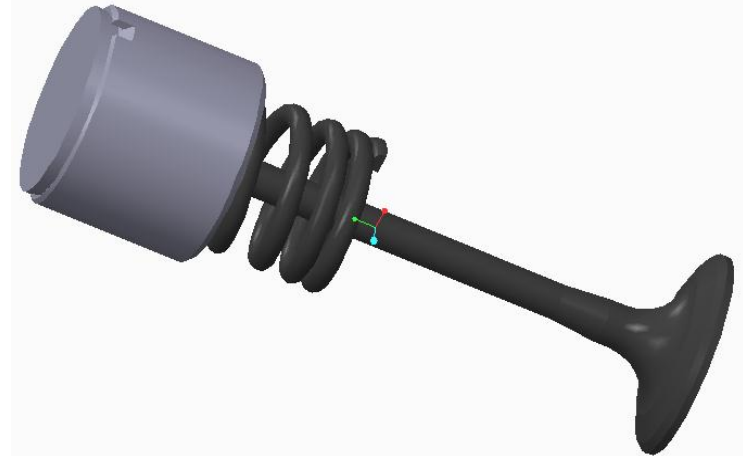
# Connection Creator – specs

## SysML Block/Instance-Creo Data Map



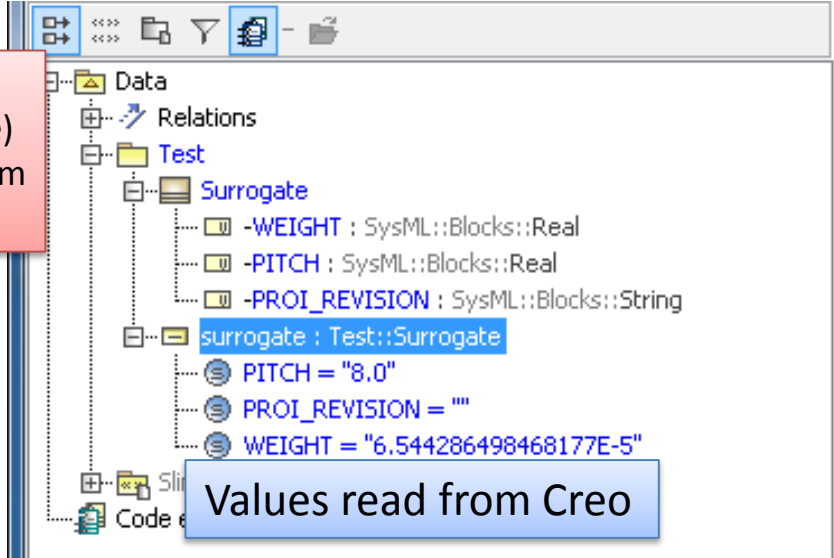
Step 2: A surrogate SysML block element is generated with the Creo parameters. This block represents the Creo model for the system engineer.

The screenshot shows a SysML model with a 'Data' package containing a 'Test' package. Inside 'Test', there is a 'Surrogate' block. The 'Surrogate' block has three parameters: '-WEIGHT : SysML::Blocks::Real', '-PITCH : SysML::Blocks::Real', and '-PROI\_REVISION : SysML::Blocks::String'. Below these parameters, there is a 'surrogate : Test::Surrogate' instance with three constraints: 'PITCH = 0.0', 'PROI\_REVISION = ""', and 'WEIGHT = 0.0'. At the bottom of the 'Data' package, there is a 'Slim Profile [slim\_profile.mdzip]' and 'Code engineering sets'.



Step 3: The surrogate SysML block element (and corresponding instance) is connected to the Creo model. System engineer can sync parameter values.

The screenshot shows the same SysML model as in Step 2, but with a context menu open over the 'surrogate : Test::Surrogate' instance. The menu options are: 'New Element', 'New Relation', 'Open in New Tab', 'Slim', 'Creo', 'Specification', and 'Enter'. The 'Creo' option is highlighted, and a sub-menu is visible with the options 'Connect' and 'Sync Creo to Instance'.

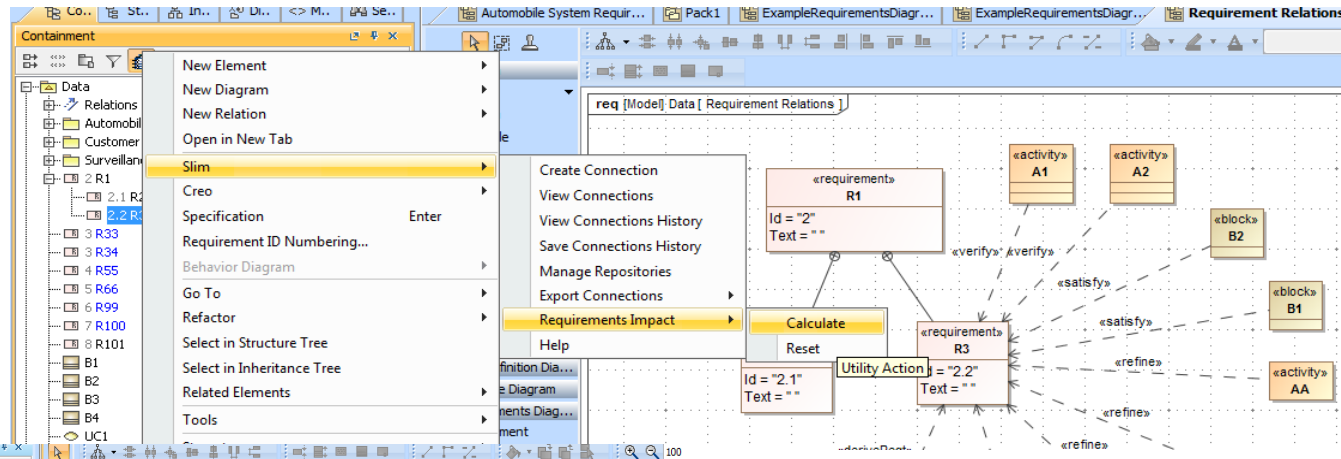


Values read from Creo

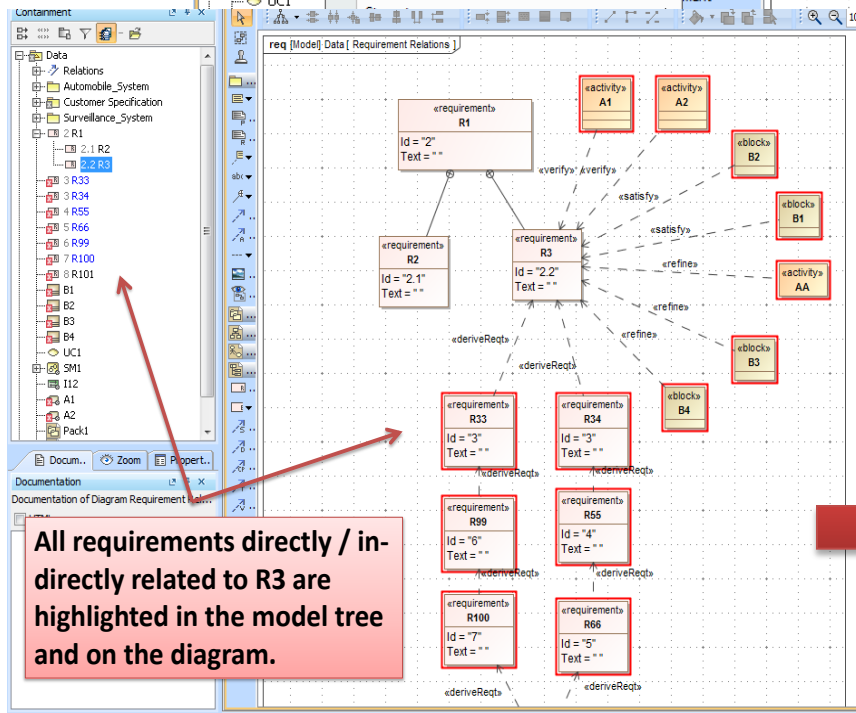
The screenshot shows the same SysML model as in Step 2, but with updated parameter values for the 'surrogate : Test::Surrogate' instance. The values are: 'PITCH = "8.0"', 'PROI\_REVISION = ""', and 'WEIGHT = "6.544286498468177E-5"'. A blue box at the bottom of the screenshot contains the text 'Values read from Creo'.



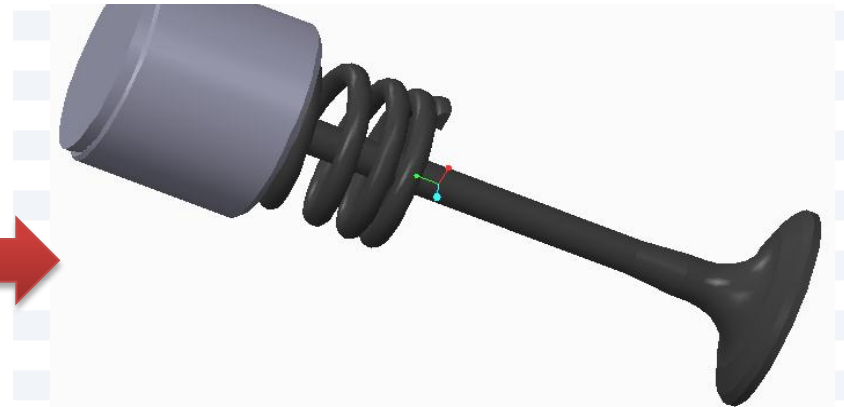
# Check Requirement Impact (Total System Model)




Connections allow us to trace the impact of requirement changes to the specific CAD parts in the PLM system



All requirements directly / indirectly related to R3 are highlighted in the model tree and on the diagram.



# Contents

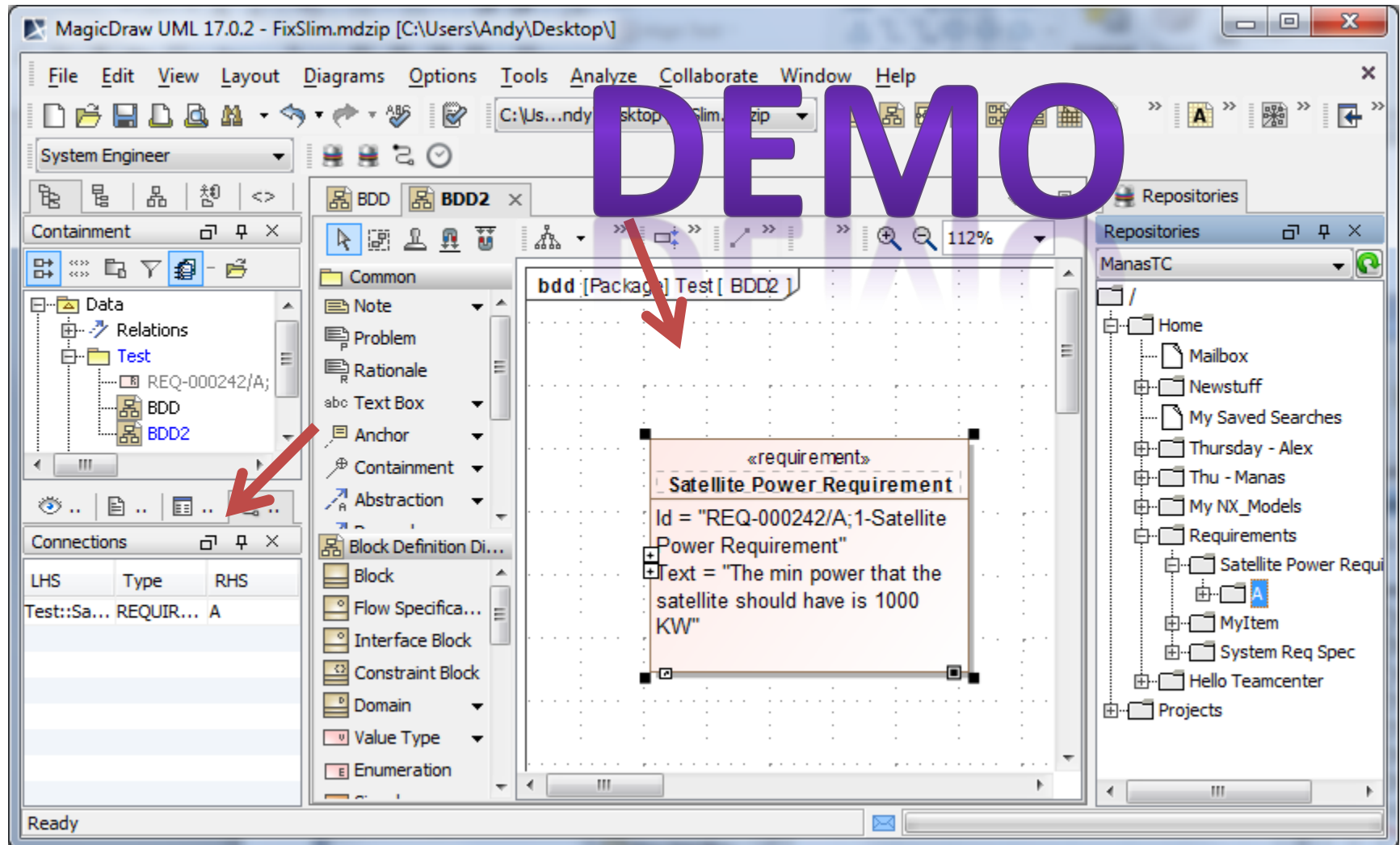
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# *Advanced Requirements Management with SLIM (Ford)*

- *SysML Requirements* – connect requirements to system architecture, analyses, and test cases in details (qualitative and quantitative)
- *Teamcenter Requirements* – manage and version control a large set of requirements across the entire mission
- With SLIM, system engineers can
  - **view TC requirements in SysML,**
  - **connect SysML and TC requirements,**
  - **push new SysML requirements to TC**

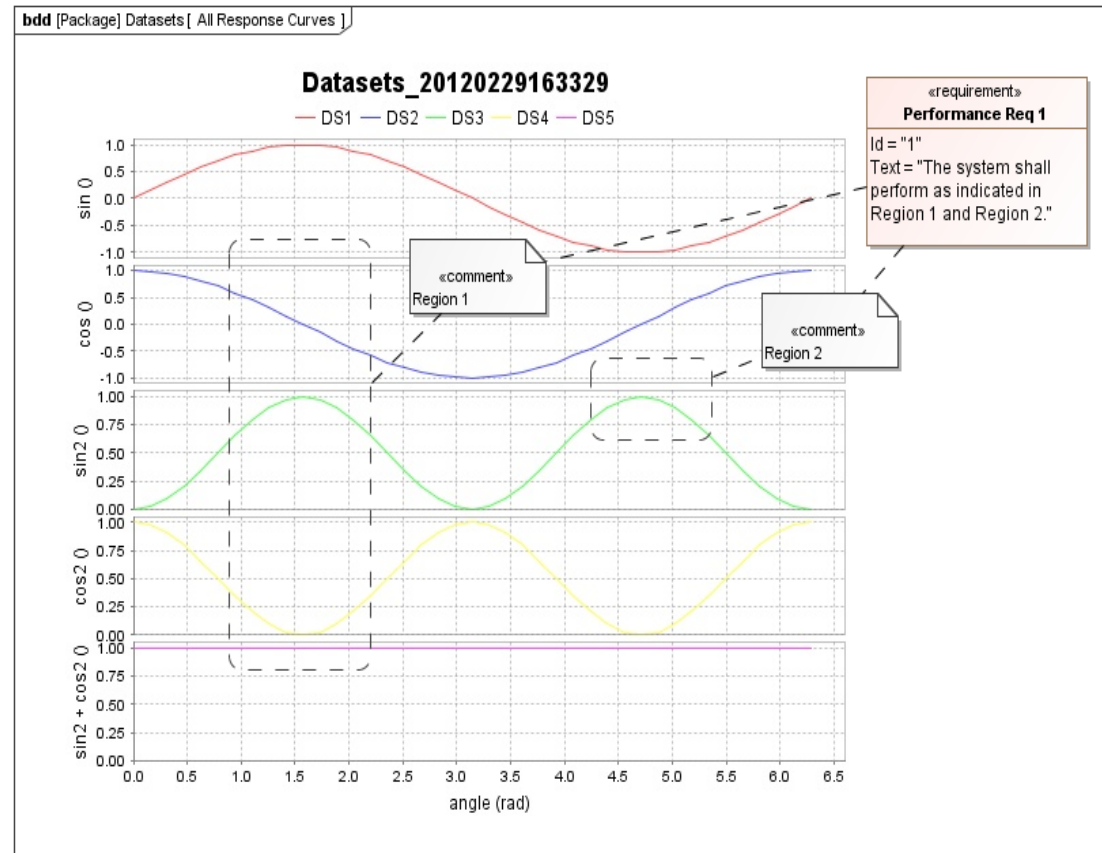
# Drag-and-Drop Requirements from a Requirements Management Tool to SysML

## *(Teamcenter and MagicDraw example)*



# Response-Based Requirements (Ford)

- *Response-based Requirements* - Defining requirements using desired system response
- Connecting requirement definitions to rich media – images, video, live network feeds, cloud content.



# Domain-specific Apps based on SLIM

## Manufacturing Capability Modeling Environment

### (DARPA AVM / iFAB Program)

**Query**

producedFeatures: Through Hole

allowable materials

allowable materials

allowable input shapes

Exclude:

**Instances**

Type	spindle - max.spe	weight	dimension -	spindle - tag	dimension	has CNC controller	spindle -
RadialDrillMachine	1920.0	4990.0	2844.79999	MT5	1397.0	no	40.0
RadialDrillMachine	2190.0	9072.0	3683.0	1244.6	no	20.0	20.0
RadialDrillMachine	1250.0	11000.0	3990.0	MT6	1400.0	no	16.0
RadialDrillMachine	1550.0	2100.0	2738.0	1150.0	648.0	no	45.0
CNCDrillingAndApp	12000.0	1905.0	2440.0	BT/30	1702.0	yes	50.0
CNCDrillingAndApp	24000.0	3500.0	2467.0	BBT30	2575.0	yes	50.0
CNCDrillingAndApp	10000.0	1500.0	1500.0	1500.0	1500.0	yes	150.0
CNCDrillingAndApp	500.0	3500.0	800.0	MT	yes	120.0	120.0
CNCDrillingAndApp	650.0	5500.0	800.0	BT40	yes	90.0	90.0
ManualDrillPress	3610.0	251.0	2057.4	MT3	711.1999	yes	150.0
ManualDrillPress	2000.0	373.0	1727.19999	MT3	635.0	yes	130.0
ManualDrillPress	3480.0	166.0	1710.0	MK/MT3	400.0	yes	95.0
ManualDrillPress	1500.0	490.0	2285.0	370.0	470.0	yes	25.0

### M-Library Web Dashboard

Search and query M-Library

**All Classes**

AuthProvider  
Concept  
DataBuilder  
DataProvider  
Documentation  
Model  
MService  
MServiceFactory  
MServiceInstantiationException  
MServiceProvider  
Named  
Property  
Type  
TypeComplex  
TypeKind  
TypePrimitive  
User

**Package Class Use Tree Deprecated Index Help**

Prev Class Next Class Frames No Frames

Summary: Nested | Field | Constr | Method Detail: Field | Constr | Method

com.intercax.macme.model

**Interface Concept**

All Superinterfaces:  
Named, java.io.Serializable

public interface Concept  
extends Named

This interface represents all M-SysML concepts, such as manufacturing process. It provides the methods to access the concept and its properties.

### M-Library Java API

Programmatically access M-SysML knowledge graph and M-Library

830+ concepts



### M-SysML Knowledge Graph

Knowledge-based representation of manufacturing concepts and related models

### M-Library Databases

**M-Library Excel Import/Export**

Export instances as Excel spreadsheets, and import spreadsheets to update M-Library

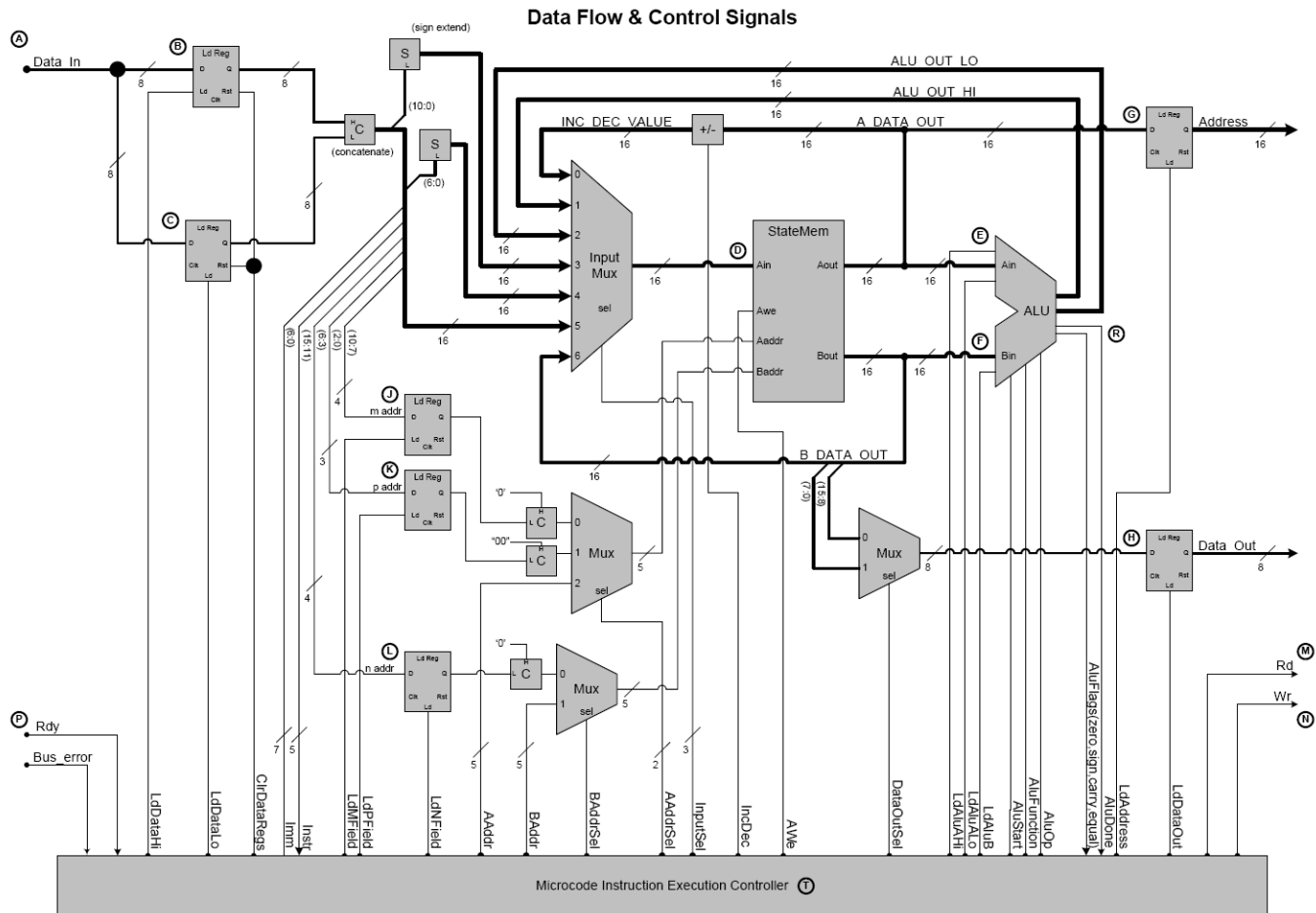
Type	Machine	Process	Tool	Feature	Shape	Material	Operators
AuthProvider	178.6	1012.2	4300.9	Clamping	CNC2400		
Concept	1840	1770	1734	Clamping	LC2500EX		
DataBuilder	1840	1770	1734	Clamping	LC2500EX		
DataProvider	1840	1770	1734	Clamping	LC2500EX		
Documentation	1840	1770	1734	Clamping	LC2500EX		
Model	1840	1770	1734	Clamping	LC2500EX		
MService	1840	1770	1734	Clamping	LC2500EX		
MServiceFactory	1840	1770	1734	Clamping	LC2500EX		
MServiceInstantiationException	1840	1770	1734	Clamping	LC2500EX		
MServiceProvider	1840	1770	1734	Clamping	LC2500EX		
Named	1840	1770	1734	Clamping	LC2500EX		
Property	1840	1770	1734	Clamping	LC2500EX		
Type	1840	1770	1734	Clamping	LC2500EX		
TypeComplex	1840	1770	1734	Clamping	LC2500EX		
TypeKind	1840	1770	1734	Clamping	LC2500EX		
TypePrimitive	1840	1770	1734	Clamping	LC2500EX		
User	1840	1770	1734	Clamping	LC2500EX		

### M-Library Excel Import/Export

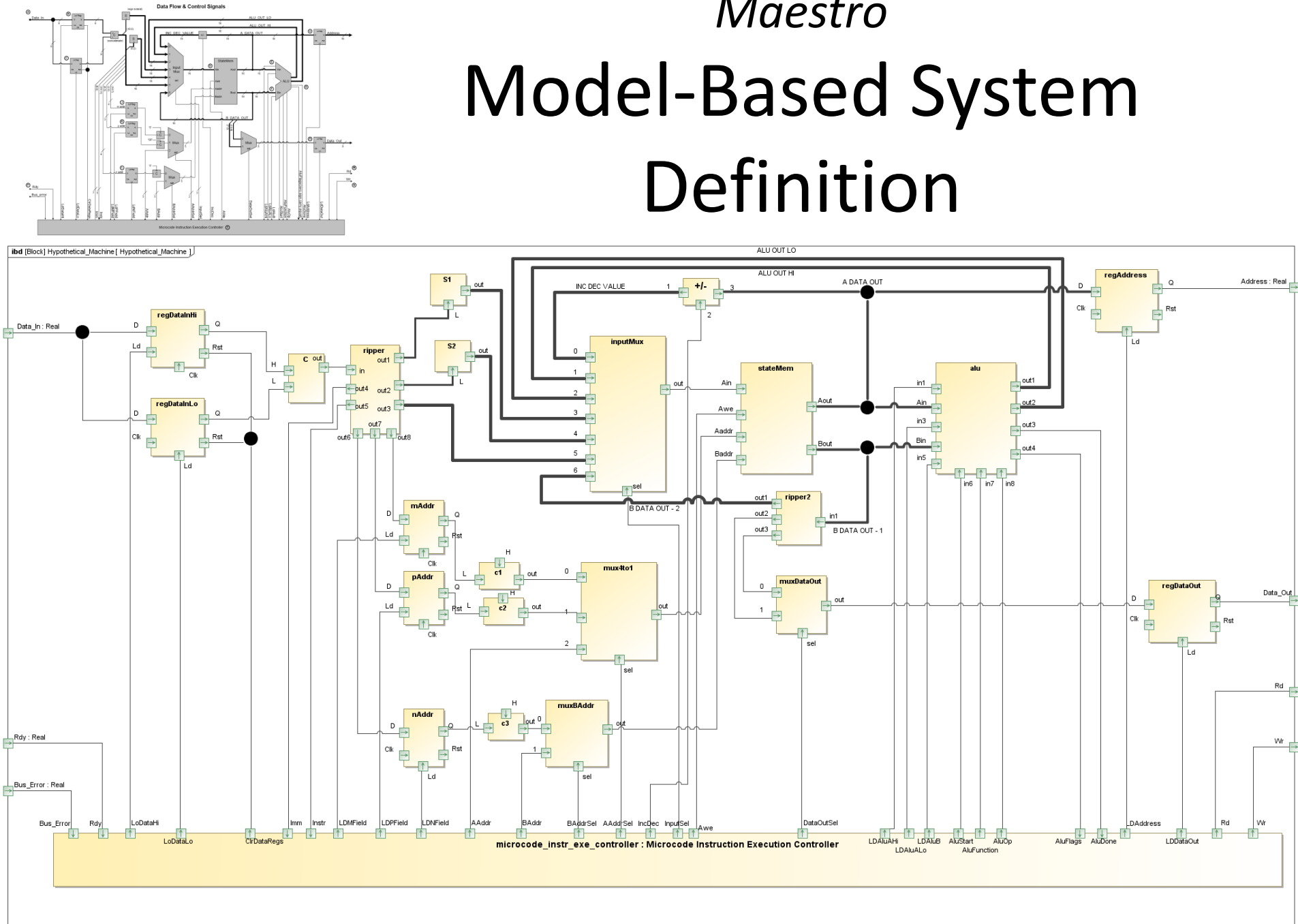
Export instances as Excel spreadsheets, and import spreadsheets to update M-Library

# Document-based system definition

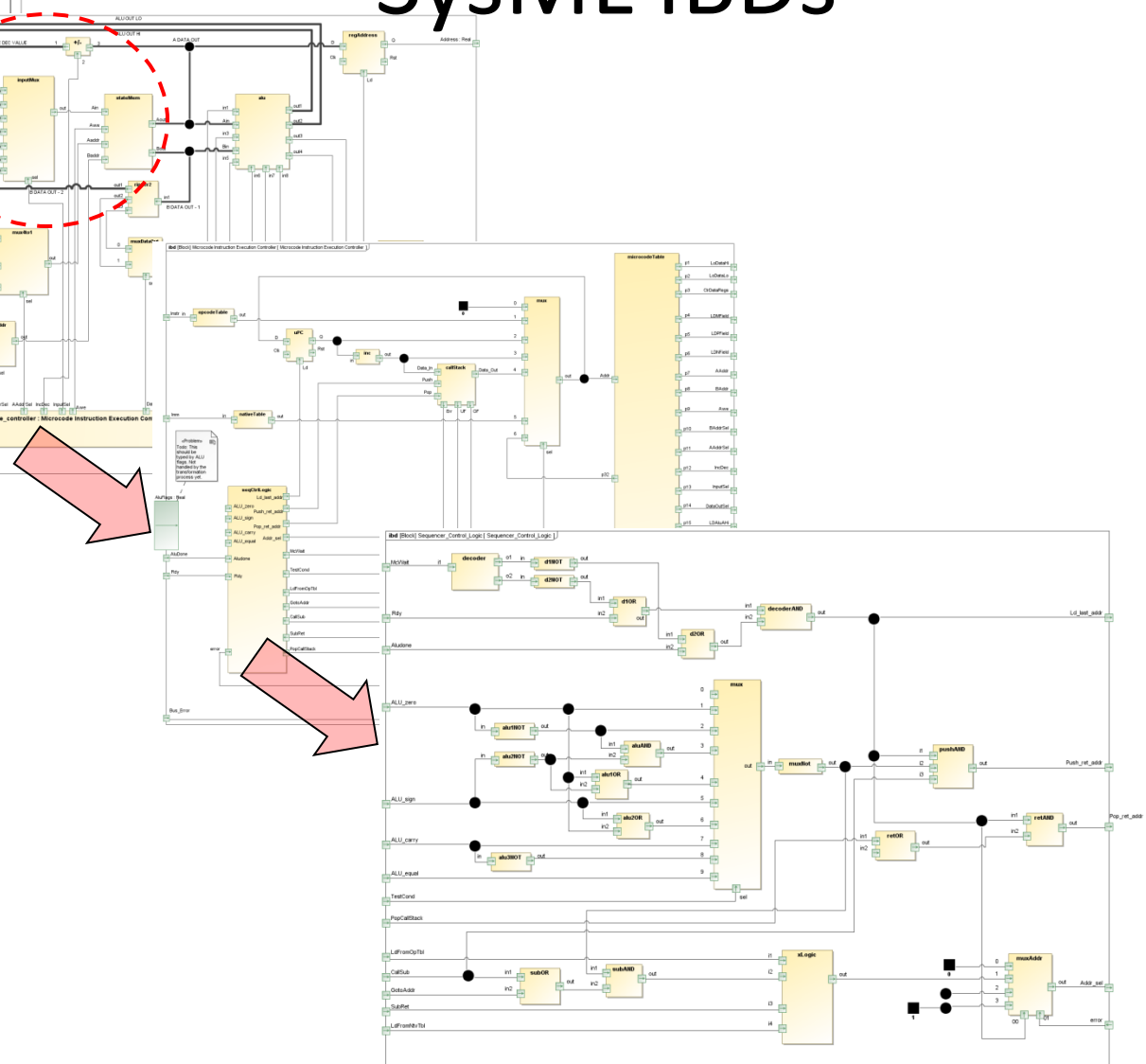
**INCOSE IS 2012 Paper:** [http://omgsysml.org/Maestro\\_SysML\\_DSL\\_Bajaj\\_INCOSE-IS-2012.pdf](http://omgsysml.org/Maestro_SysML_DSL_Bajaj_INCOSE-IS-2012.pdf)



# Maestro Model-Based System Definition





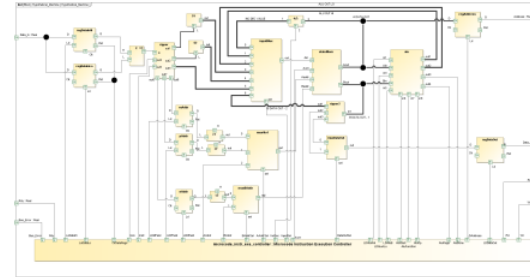
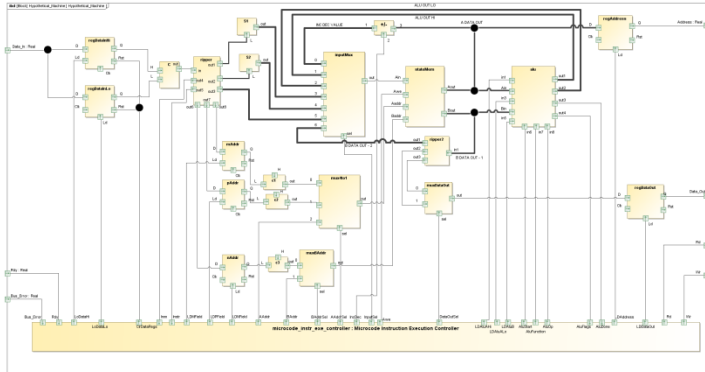


# Generating Simulation Models

## SysML, XML, and Java

## SysML-based Analytical Model + design-analysis relationships

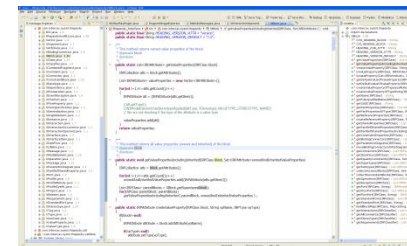
# System Design Representation (SysML)



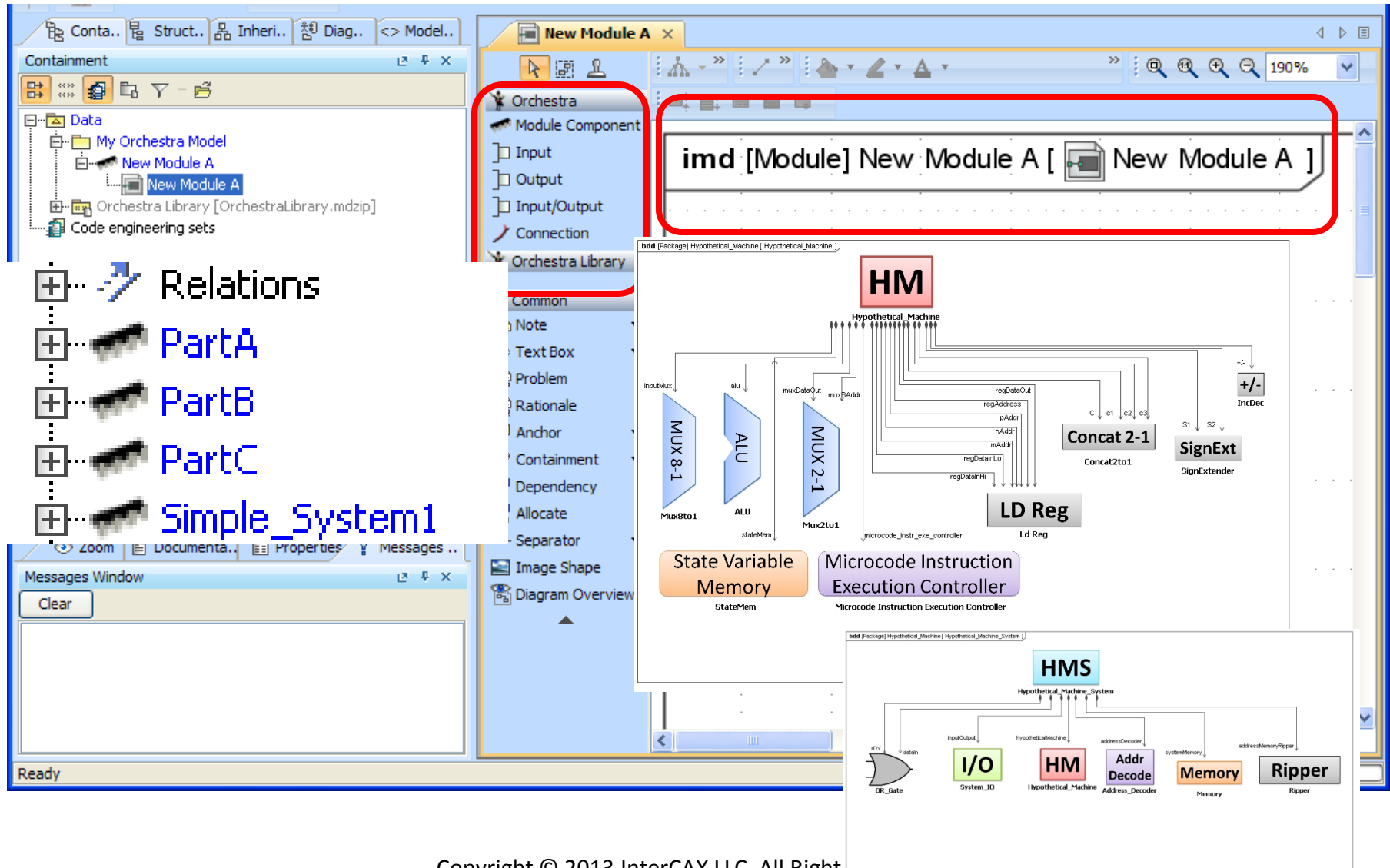
## XML-based analytical model structure

[illegible]

Java based simulation model



# Maestro – A visual modeling environment for designers and analysts (SysML DSL Plugin for MagicDraw)



# Questions?

**Manas Bajaj, PhD**

Chief Systems Officer

InterCAX LLC

email: [manas.bajaj@intercax.com](mailto:manas.bajaj@intercax.com)

web: [www.intercax.com](http://www.intercax.com) ; [www.intercax.com/mbse](http://www.intercax.com/mbse)

twitter: [@InterCAX](https://twitter.com/InterCAX)


75 5<sup>th</sup> Street NW, Suite 312

Atlanta, GA 30308

USA

+1-404-592-6897, x101

# Contents

- Motivation
- What is SLIM?
  - Conceptual Architecture
  - Use Cases
- SLIM – Bridging MBSE and PLM
- SLIM – NASA SBIR Phase 1 Project
- SLIM – Current capabilities and tools 
- SLIM - Applications

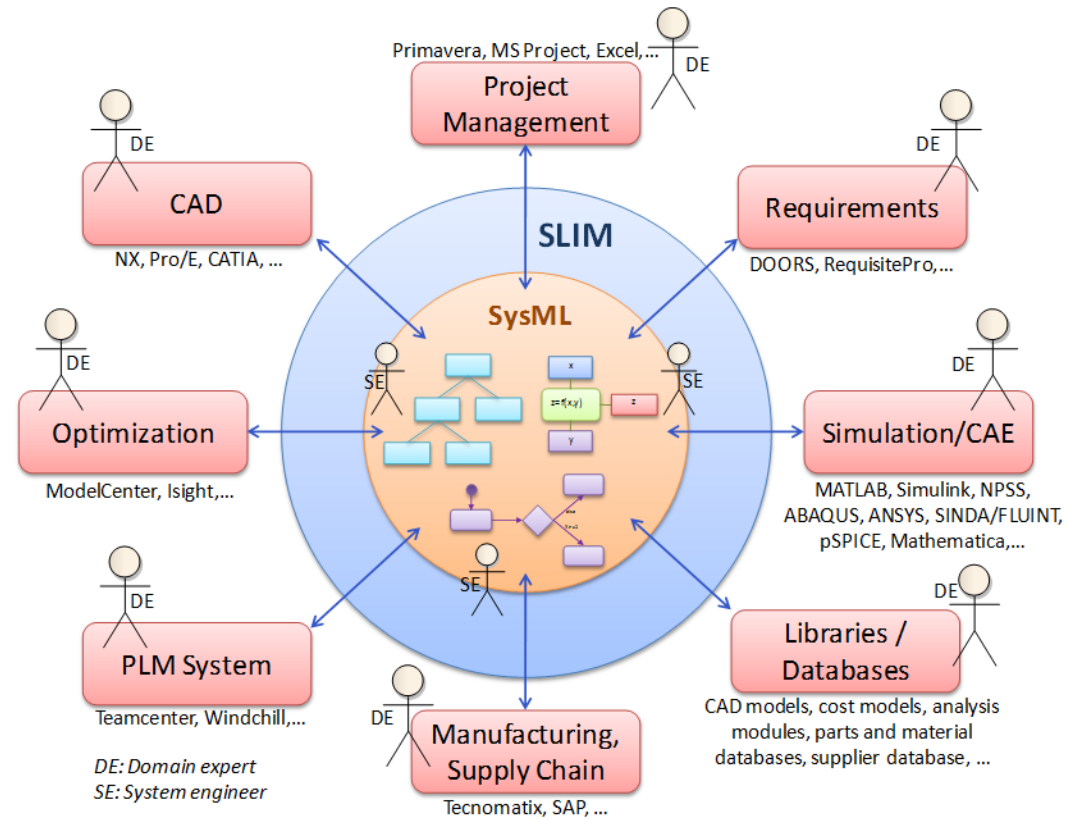
# SLIM deployed as SysML plugins

**ParaMagic® 17.0.1**  
(MagicDraw 17.0.1)

**ParaSolver™ 2**  
(Artisan Studio 7.4)

**Melody™ 3**  
(Rhapsody 7.6)

**Solvea™ 1**  
(Enterprise Architect 9.3)



[www.intercax.com/products](http://www.intercax.com/products)

# Standard Products

[www.intercax.com/products](http://www.intercax.com/products)

- SysML Parametric Analysis and Integration Products
  - **ParaMagic<sup>®</sup>** for **MagicDraw** (since Jul 2008)
    - [www.magicdraw.com/paramagic](http://www.magicdraw.com/paramagic)
    - [www.intercax.com/paramagic](http://www.intercax.com/paramagic)
  - **Melody<sup>™</sup>** for **Rhapsody** (since Jan 2010)
    - [www.intercax.com/melody](http://www.intercax.com/melody)
  - **Solvea<sup>™</sup>** for **Enterprise Architect** (since Mar 2011)
    - [www.intercax.com/solvea](http://www.intercax.com/solvea)
  - **ParaSolver<sup>™</sup>** for **Artisan Studio** (since Jan 2011)
    - [www.atego.com/products/artisan-studio-pararesolver/](http://www.atego.com/products/artisan-studio-pararesolver/)
    - [www.intercax.com/parasolver](http://www.intercax.com/parasolver)

# SysML Parametric Analysis and Integration Technology

- Represent fine-grained relationships between models (similar to parametric modeling in CAD)
- Execute math relationships inside SysML Models (next-generation spreadsheets for SE)
- Connect external models to SysML – MS Excel, MATLAB/Simulink, Databases, CAD/CAE,...
- Simulations, Analysis, Trade Studies, Optimization, Requirements Checking, Risk Assessment, ... & more



# ParaMagic<sup>®</sup> for MagicDraw

ParaMagic(TM) 17.0.1 - System01

Name	Qualified Name	Type	Causality	Values
LittleEyeSystem	LittleEye::LittleEyeInstance01::System01	LittleEyeSystem		
MilesScannedPerHour		Real	given	40
NumberAvailableCrews		Real	undefined	?????
NumberAvailableFuelLoads		Real	undefined	?????
NumberAvailablePlanes		Real	undefined	?????
NumberAvailableSystems		Real	undefined	?????
NumberMilesScannedPer 24Hours		Real	target	?????
LittleAircraft	LittleEye::LittleEyeInstance01::Aircraft01	LittleEyeAircraft		
DutyCycle_CameraRefit		Real	given	0.09
DutyCycle_Maintenance		Real	given	0.02
DutyCycle_Plane		Real	undefined	?????
DutyCycle_Turnaround		Real	given	0.23
NumberAvailablePlanes		Real	undefined	?????
NumberAvailablePlanesByDay		Real	undefined	?????
NumberAvailablePlanesByNight		Real	undefined	?????
NumberDayCameras		Real	given	3
NumberNightCameras		Real	given	7
NumberPlanes		Real	given	4
LittleCrew	LittleEye::LittleEyeInstance01::Crew01	LittleEyeCrew		
CrewTimeOn		Real	given	0.42
NumberAvailableCrews		Real	undefined	?????
NumberCrews		Real	given	5
LittleFuel	LittleEye::LittleEyeInstance01::Fuel01	LittleEyeFuel		
DailyFuelLoadPerPlane		Real	given	50
FuelSupplyPerDay		Real	given	250
NumberAvailableFuelLoads		Real	undefined	?????

Expand Collapse All Solve Reset Update to SysML

root ( LittleEyeSystem )


Name	Local	Oneway	Relation	Active
SAE	Y	<input checked="" type="checkbox"/>	NumberAvailableSystems=min(NumberAvailablePlanes,NumberAvailableCrews,Num...	<input checked="" type="checkbox"/>
SE	Y	<input type="checkbox"/>	NumberMilesScannedPer 24Hours=NumberAvailableSystems*MilesScannedPerHour*24	<input checked="" type="checkbox"/>
e10	Y	<input type="checkbox"/>	LittleFuel.NumberAvailableFuelLoads = NumberAvailableFuelLoads	<input checked="" type="checkbox"/>
e8	Y	<input type="checkbox"/>	LittleAircraft.NumberAvailablePlanes = NumberAvailablePlanes	<input checked="" type="checkbox"/>
e9	Y	<input type="checkbox"/>	LittleCrew.NumberAvailableCrews = NumberAvailableCrews	<input checked="" type="checkbox"/>

# SLIM's Capabilities (as of Aug 2012)

- **SysML-based Parametric Solvers** (since 2008)
  - Acausal solving of parametric models (not diagrams)
  - Complex math relations & patterns for parametric relations (e.g. topology-independent relations, define for structure – execute for block instances)
  - Support for complex SysML parametric patterns such as recursion and redefinition
  - Automated requirements verification , *response-based requirements*
  - Ability to wrap external models (e.g. MATLAB, Mathematica, Excel)
  - Concept trade studies
- **SysML Integrators**
  - Excel interface (data r/w + SysML model generation & update)
  - Database interface\*
  - MATLAB/Simulink interface
  - Mathematica interface
  - OpenModelica interface
  - CAD interface (NX, AP203/210)\*
  - CAE interface (ABAQUS, ANSYS)\*
  - STK interface\*
  - *PLM interface (Windchill, Teamcenter)\**
  - ...plus tailored interfaces

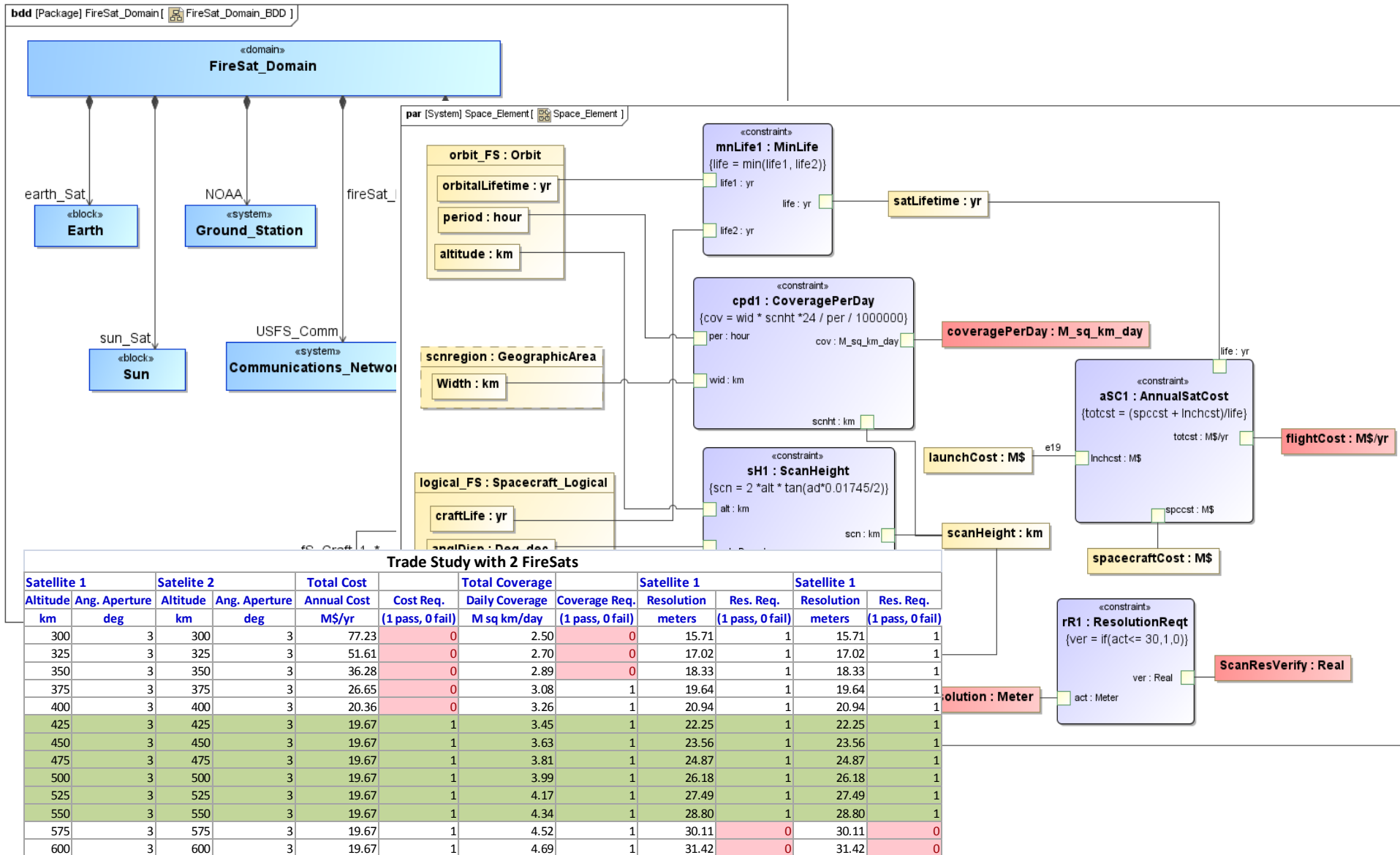
\* alpha/beta-level maturity

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# Space Systems

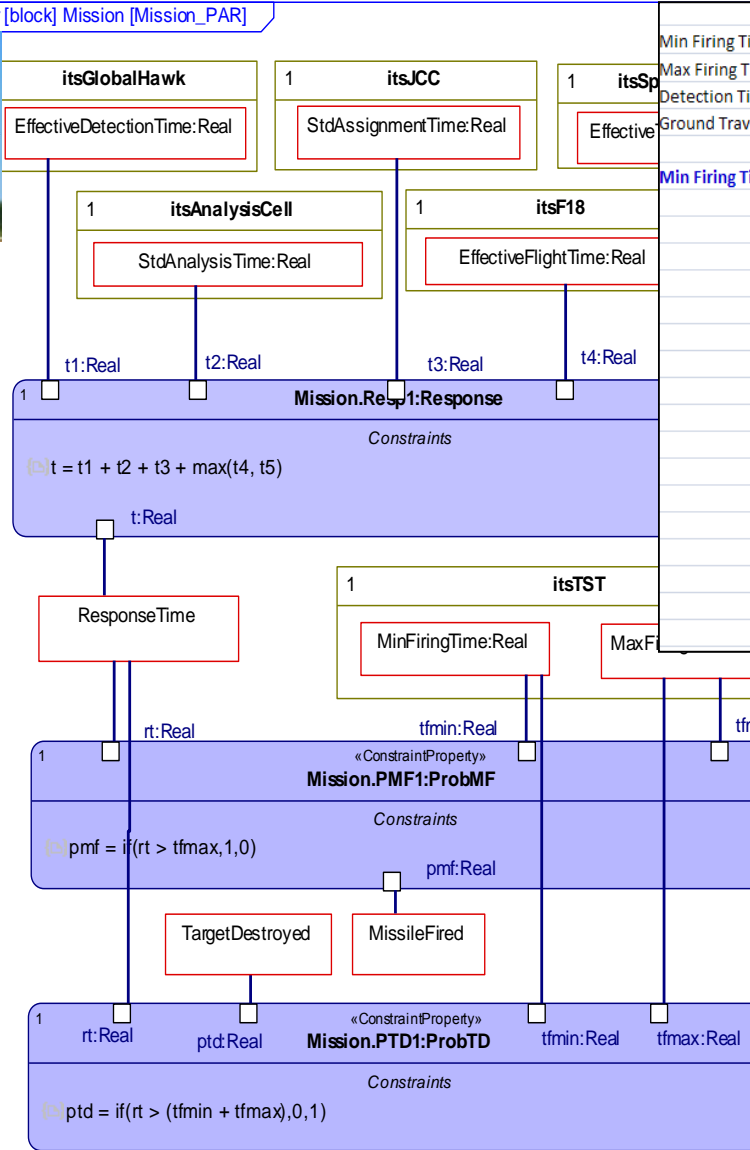
## Cost and coverage trades and req. verification



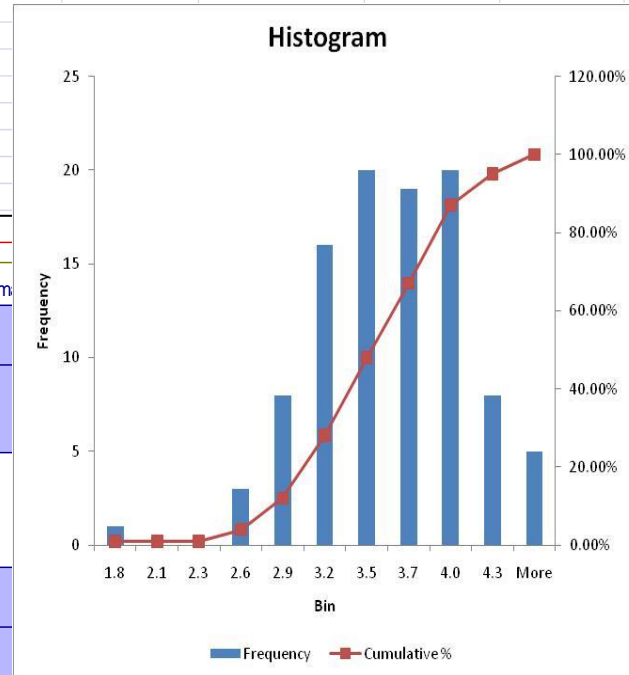
# Military and Intelligence

*Probability of mission success, mean response time*

par [block] Mission [Mission\_PAR]

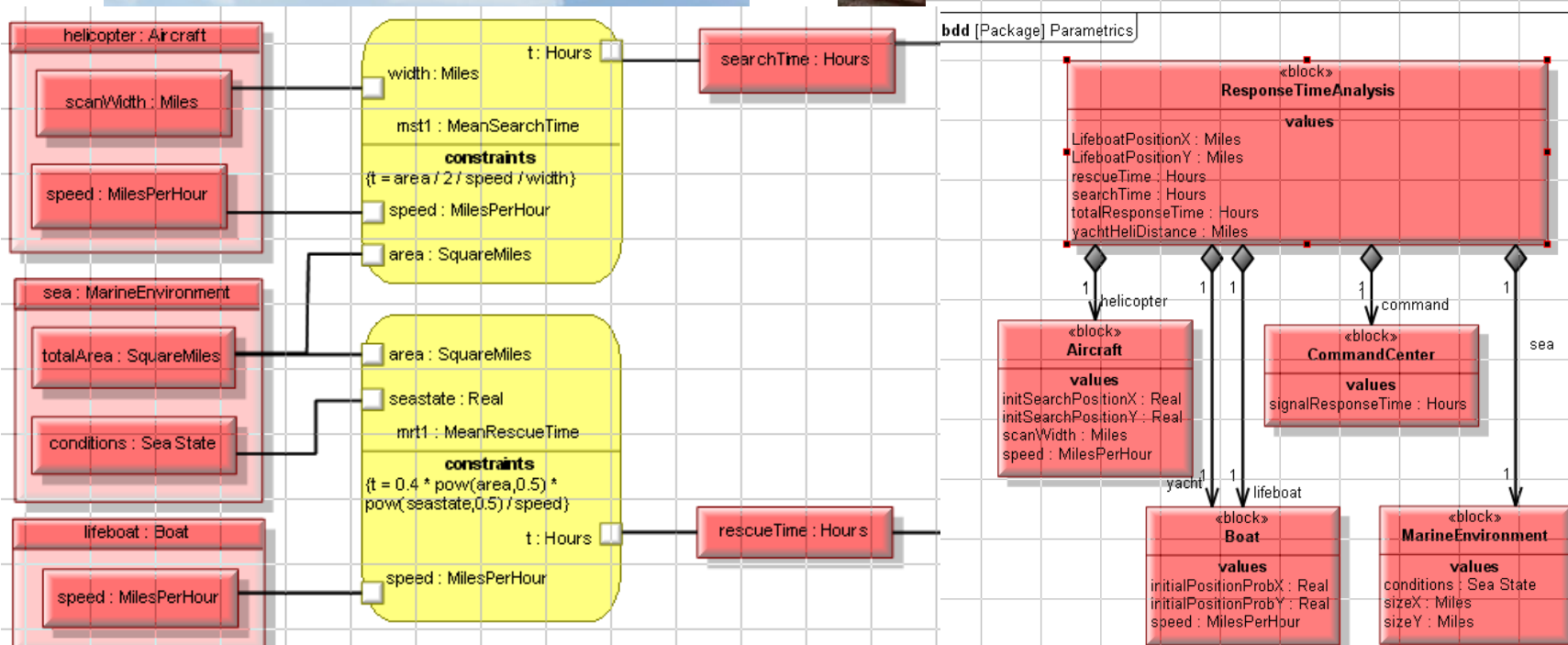


	Mean (hrs)	Variance (hrs)				
Min Firing Time	1.5	0.25	Mean Prob Missile Fired		0.36	
Max Firing Time	2.5	0.25	Mean Prob TST Destroyed		1.00	
Detection Time	4	1				
Ground Travel Time	2	0.5				
Min Firing Time	MaxFiring Time	UAV Detection Time	SF Travel Time	MissileFired?	TSTDestroyed?	Response Time
1.667	2.881	4.145	2.072	0	1	2.34
1.448	2.465	4.780	1.643	0	1	2.45
1.458	2.544	3.804	2.518	0	1	2.37
1.780	2.590	4.450	1.510	0	1	2.36
1.496	2.400	4.258	2.562	1	1	2.50
1.661	2.813	3.328	2.387	0	1	2.22
1.359	2.387	4.095	2.812	1	1	2.53
1.337	2.961	3.797	2.155	0	1	2.28
1.144	2.206	3.559	1.358	0	1	2.14
					1	2.75
					1	1.83
					1	2.57
					1	2.72
					1	2.03
					1	2.23
					1	2.54
					1	2.15



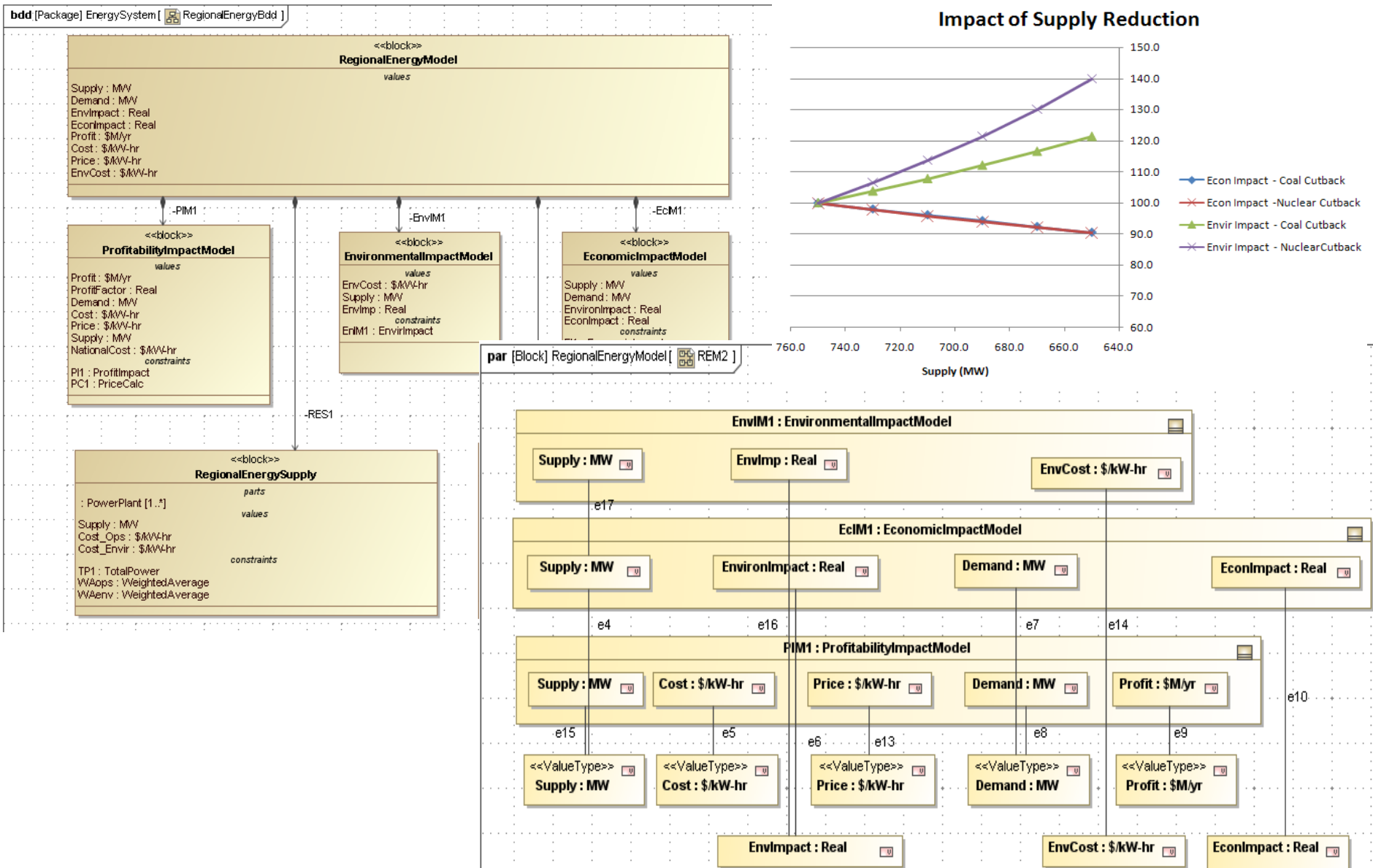
# Disaster Response

*Search & rescue area coverage and response time*



# Energy Systems

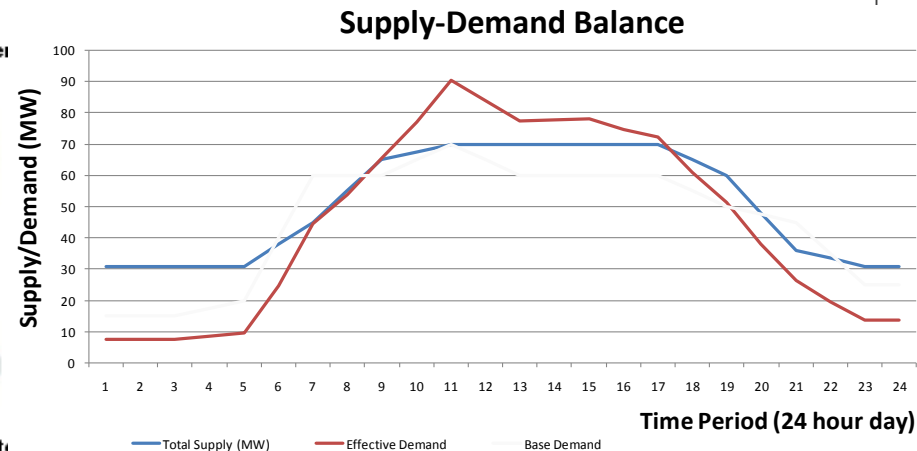
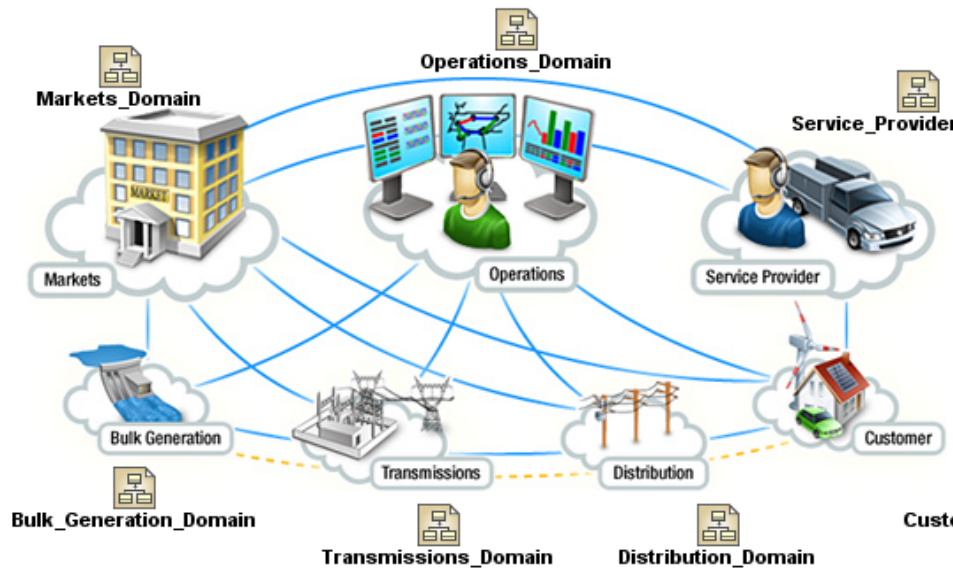
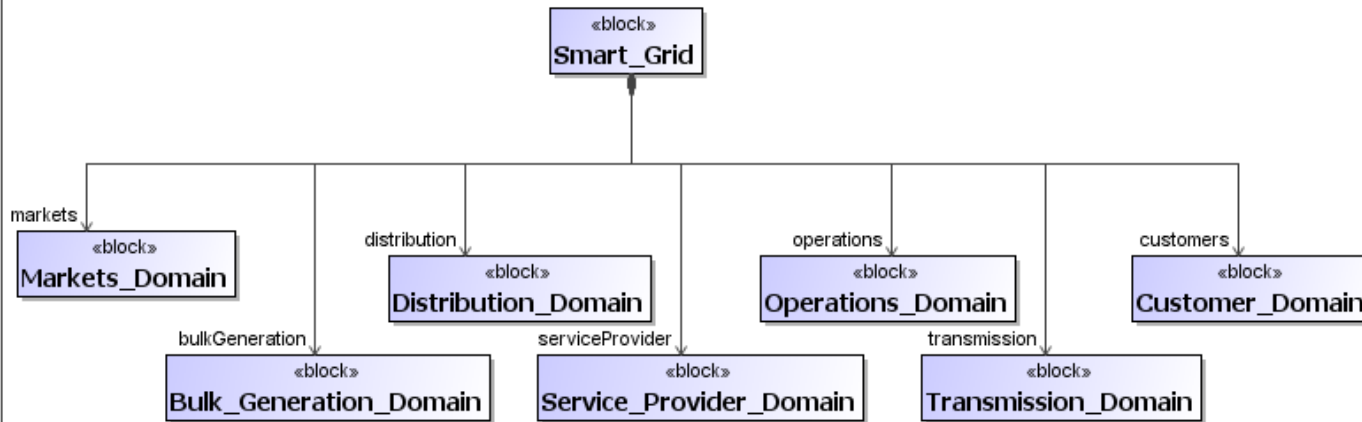
## Profitability, Environment, and Economy





# Smart Grid (supply/demand, ops cost)

bdd [Package] NIST\_Smart\_Grid\_Conceptual\_Model[ Smart\_Grid\_Domain ]

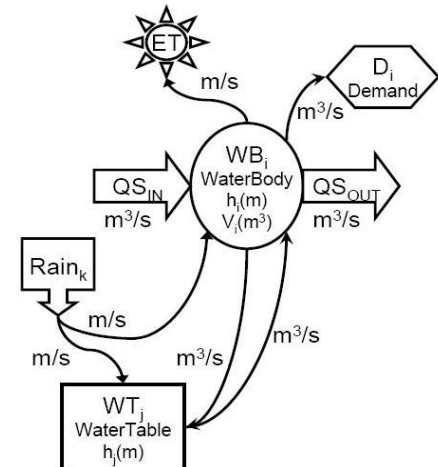
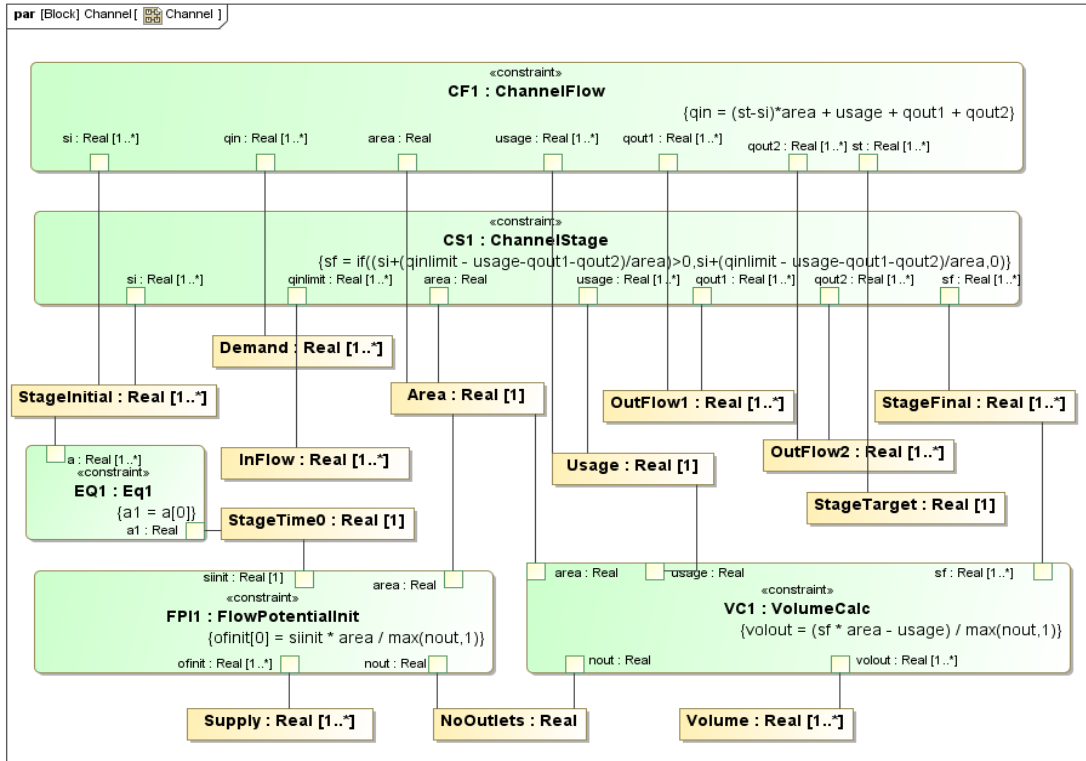
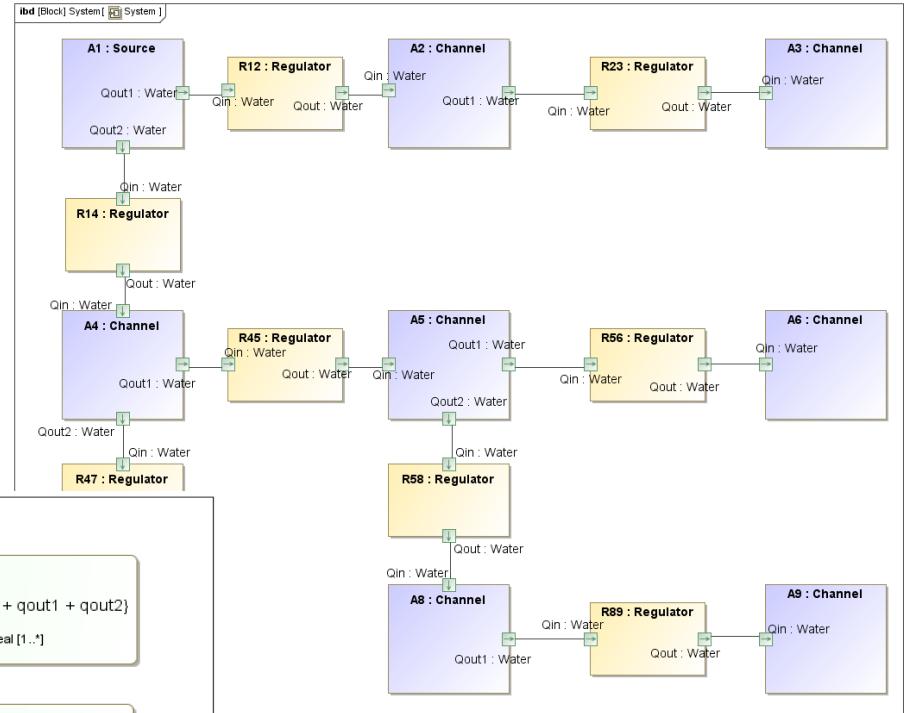
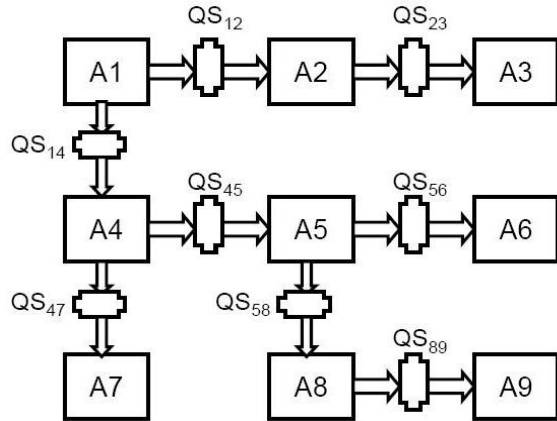


Daily Expense: SmartGrid \$60,228 DumbGrid \$66,477

For more info, visit <http://smartgrid.ieee.org/nist-smartgrid-framework>

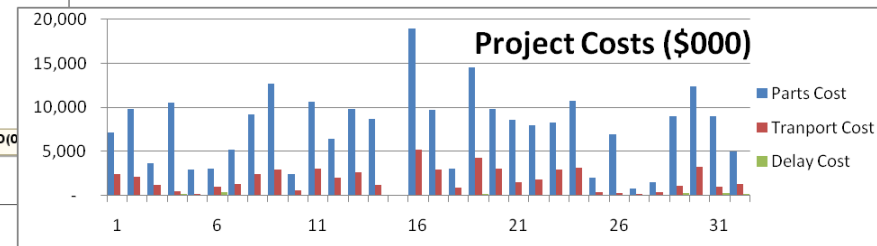
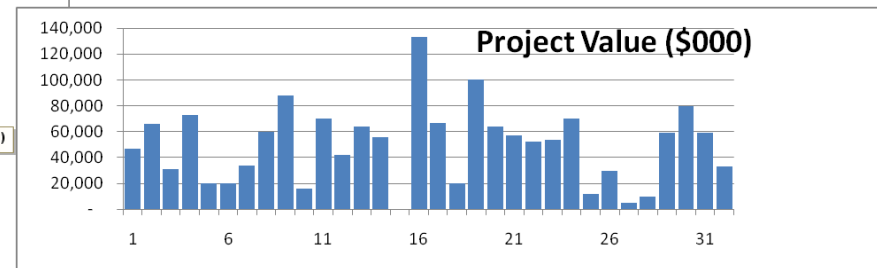
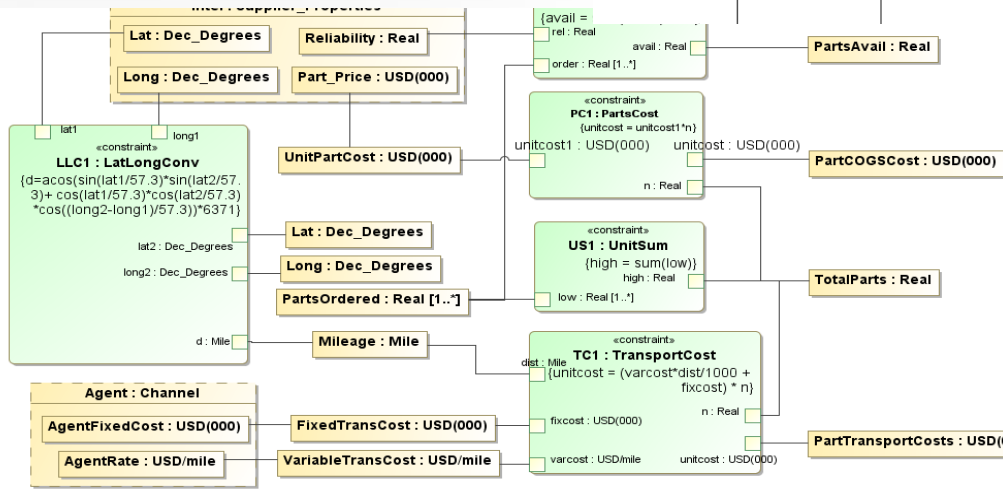
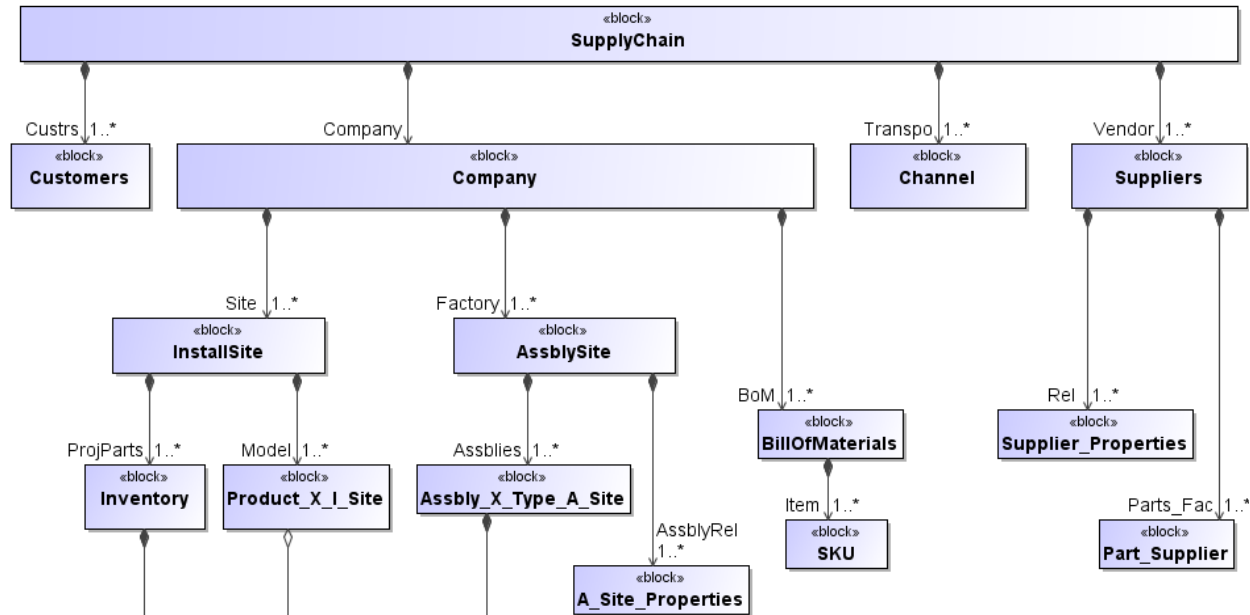


# Infrastructure Systems



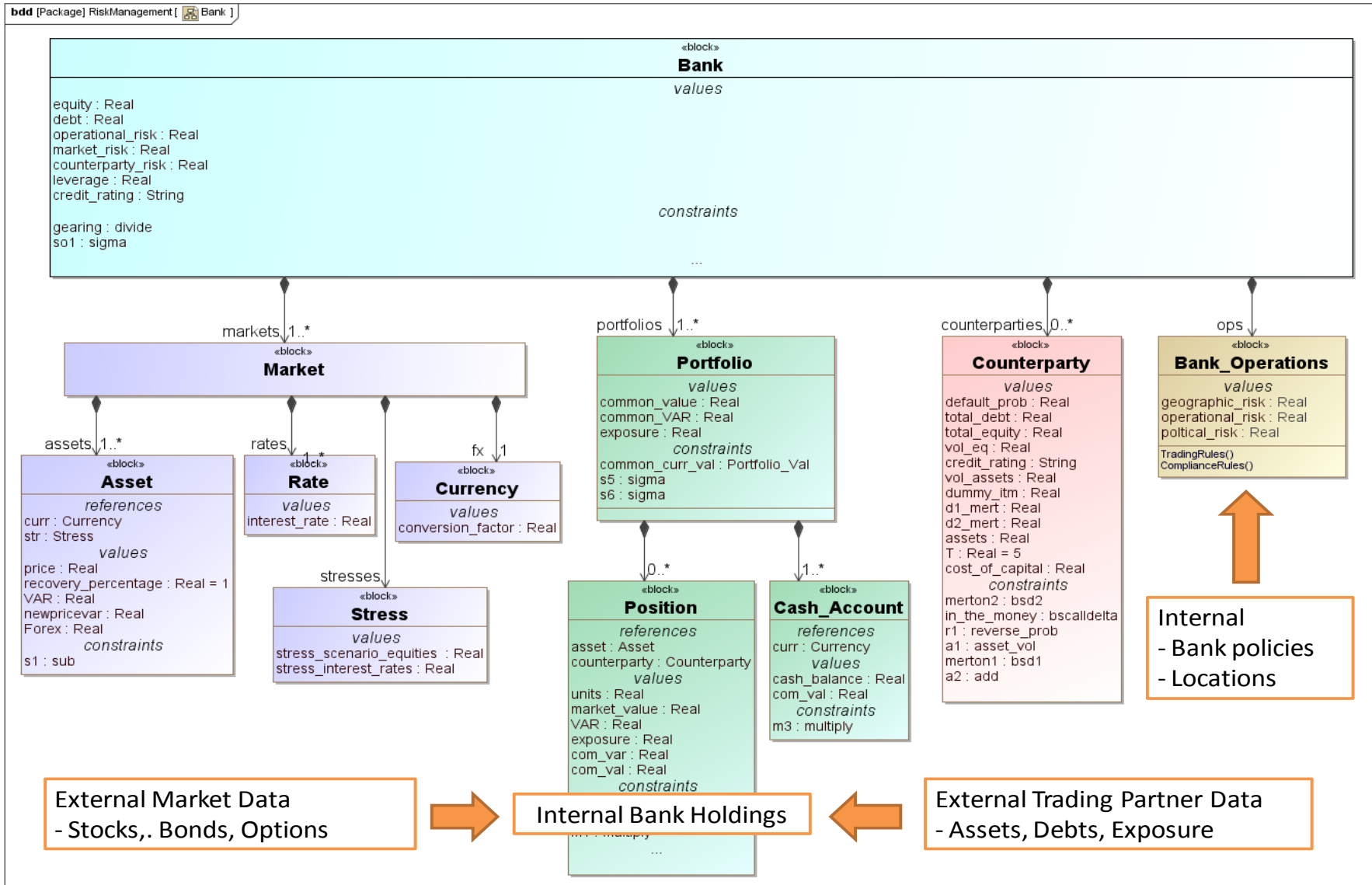
# Manufacturing and Supply Chain

## *Computing value at risk, supply-demand balance*



# Banking and Financial Systems

## *Computing risk and checking compliance*



# Questions?

**Manas Bajaj, PhD**

Chief Systems Officer

InterCAX LLC

email: [manas.bajaj@intercax.com](mailto:manas.bajaj@intercax.com)

web: [www.intercax.com](http://www.intercax.com) ; [www.intercax.com/mbse](http://www.intercax.com/mbse)

twitter: [@InterCAX](https://twitter.com/InterCAX)

75 5<sup>th</sup> Street NW, Suite 312

Atlanta, GA 30308

USA

+1-404-592-6897, x101