

Applying MBSE to the Energy Sector

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About Intercax

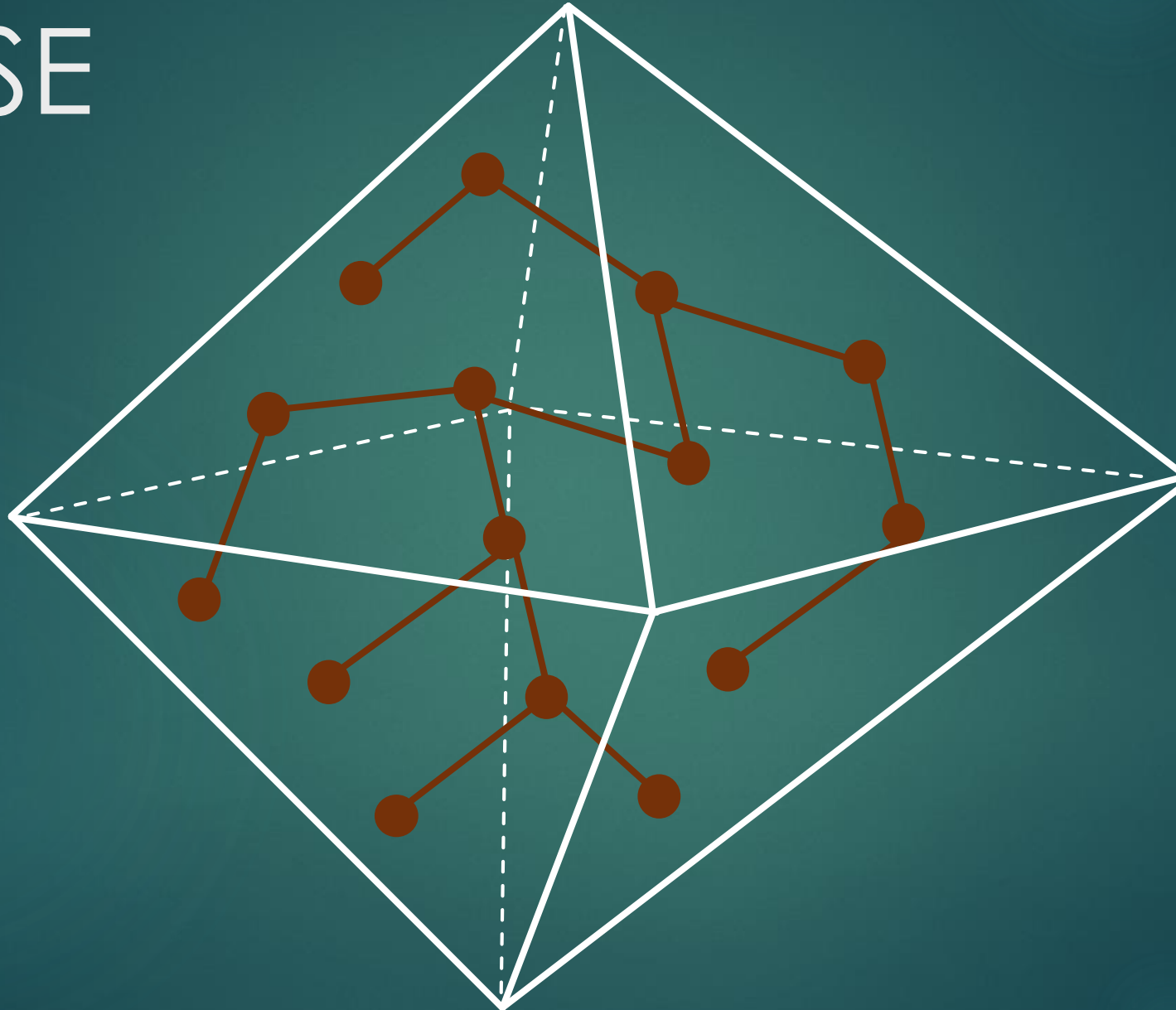


- Georgia Tech spin-off 2008
- Location: Tech Square, Atlanta; Pune IT Park, Pune, India
- Focus: Software for MBSE
 - **Syndeia** -
PLM/CAD/CAE/ALM
Integration with SysML
 - SysML parametric solvers
- Training, consulting, custom apps
 - 3500+ students since 2008
- Customers
 - Gov: NASA, DoD, DoE
 - Commercial: aero, auto, transportation, consumer goods, energy, mfg., healthcare



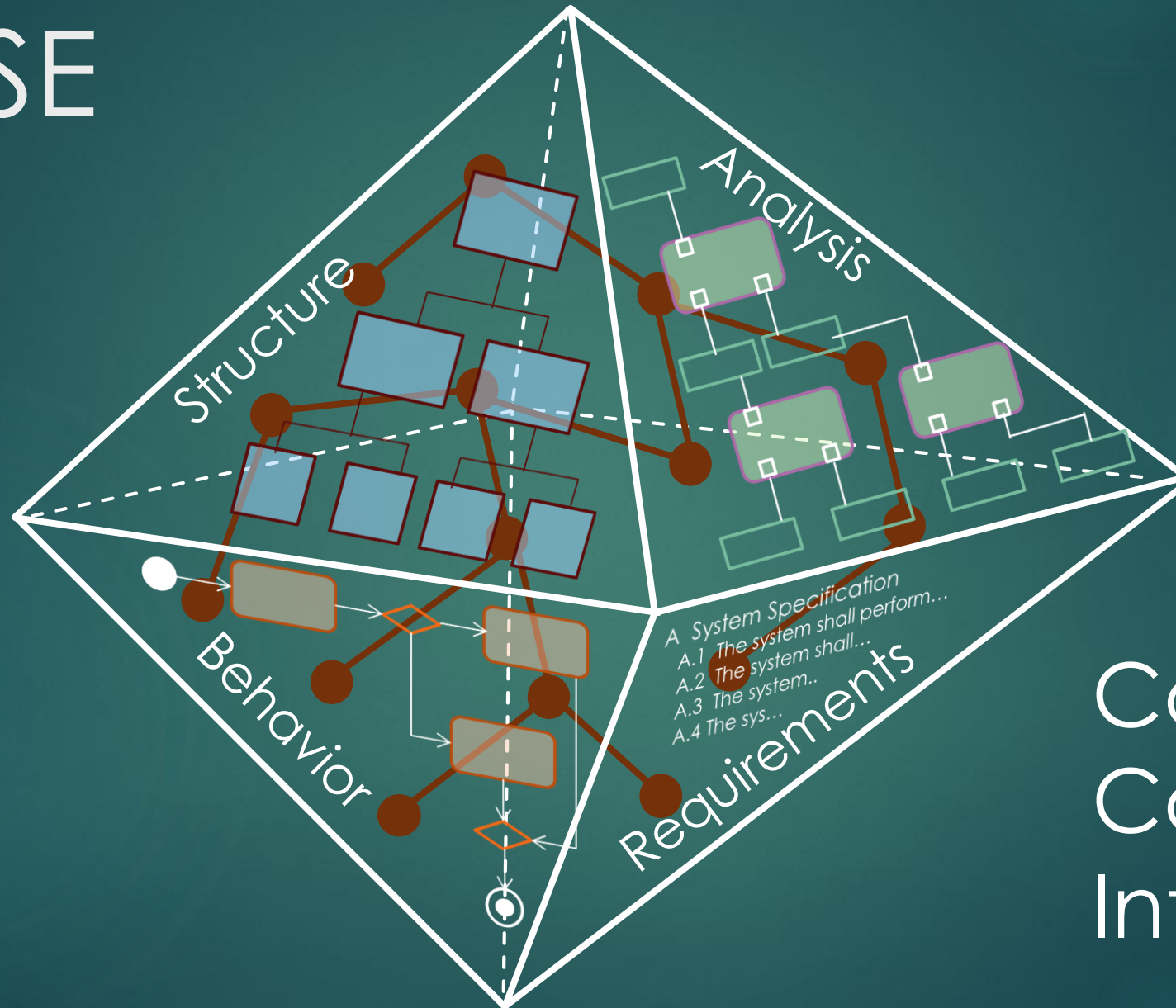
intercax

MBSE





MBSE

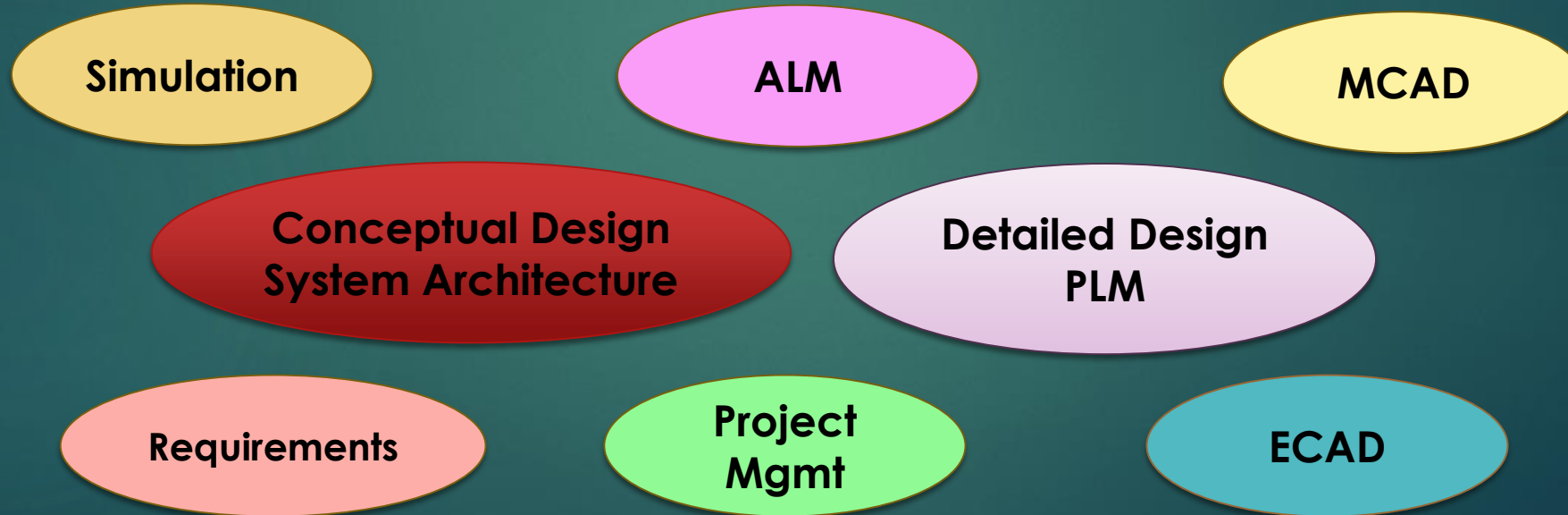


Consistency
Coherence
Integrity



The Engineering Software Universe

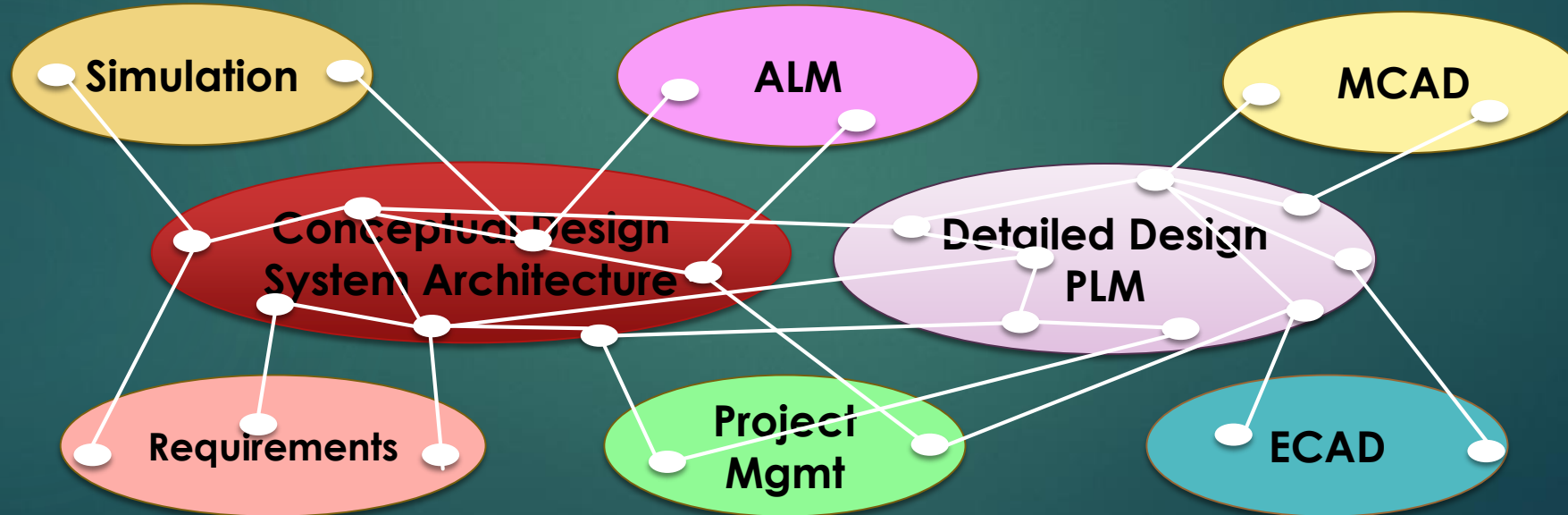
- Organizations deal with a diverse, multi-vendor engineering toolset.
- Organization create and store product/system data in a variety of tools, models and repositories: PLM, ALM, CAD, spreadsheets, SysML models...





The Engineering Software Universe

- The goal of MBE is to create a single, unified model (a Graph) extending over all the tools and data repositories.



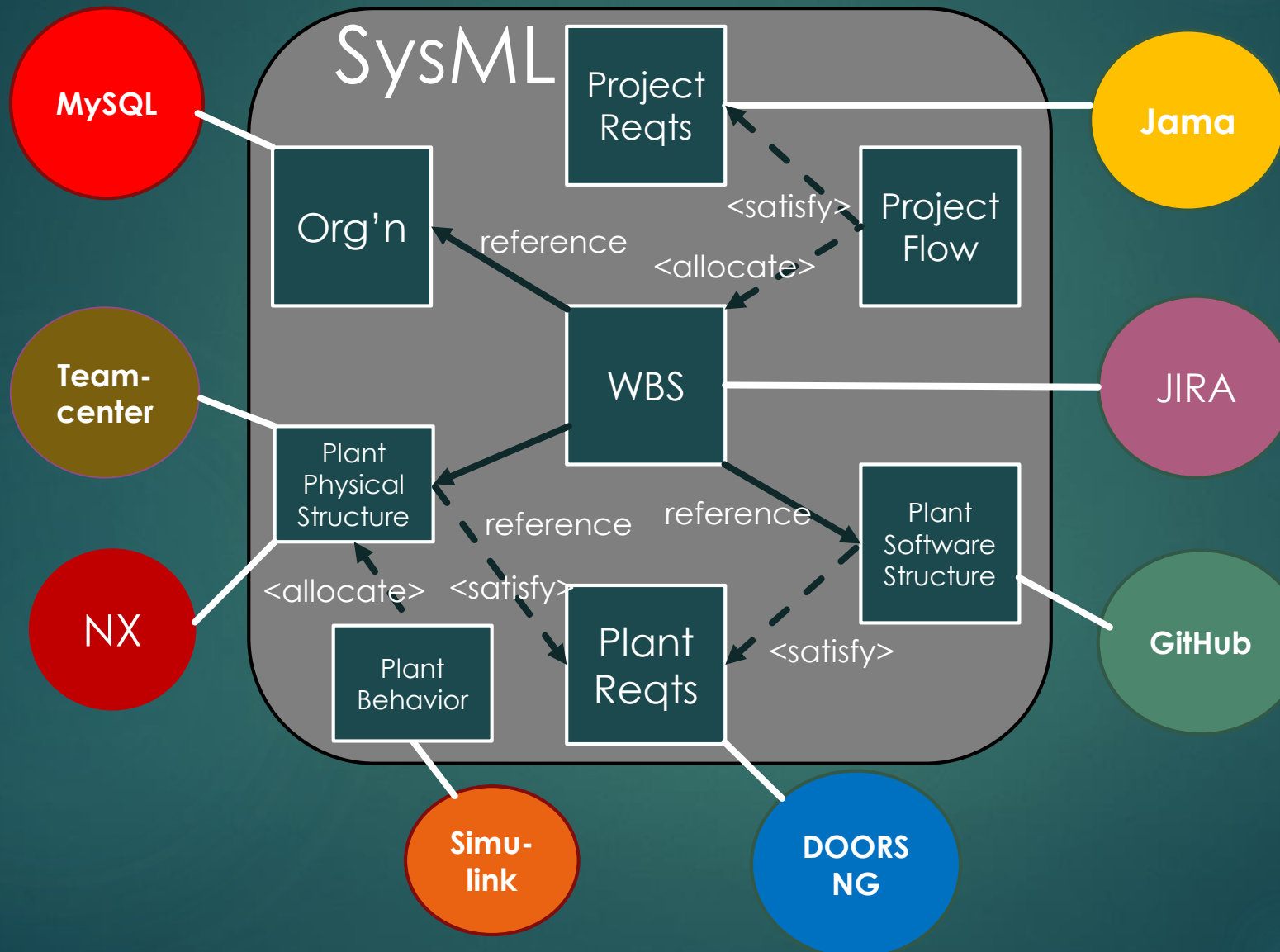
Why the Energy Sector Needs MBE

- Diversity of model types and tools
 - Multiple disciplines – electrical, mechanical, software, ...
 - Multiple purposes – design, construction, operation
 - Multiple scales – individual user to national grid
 - Multiple stakeholders – financial, environmental, ...
- Resilience, safety and security are critical
 - MBE should expose unexpected chains of causation
 - Predict emergent behaviors and vulnerabilities

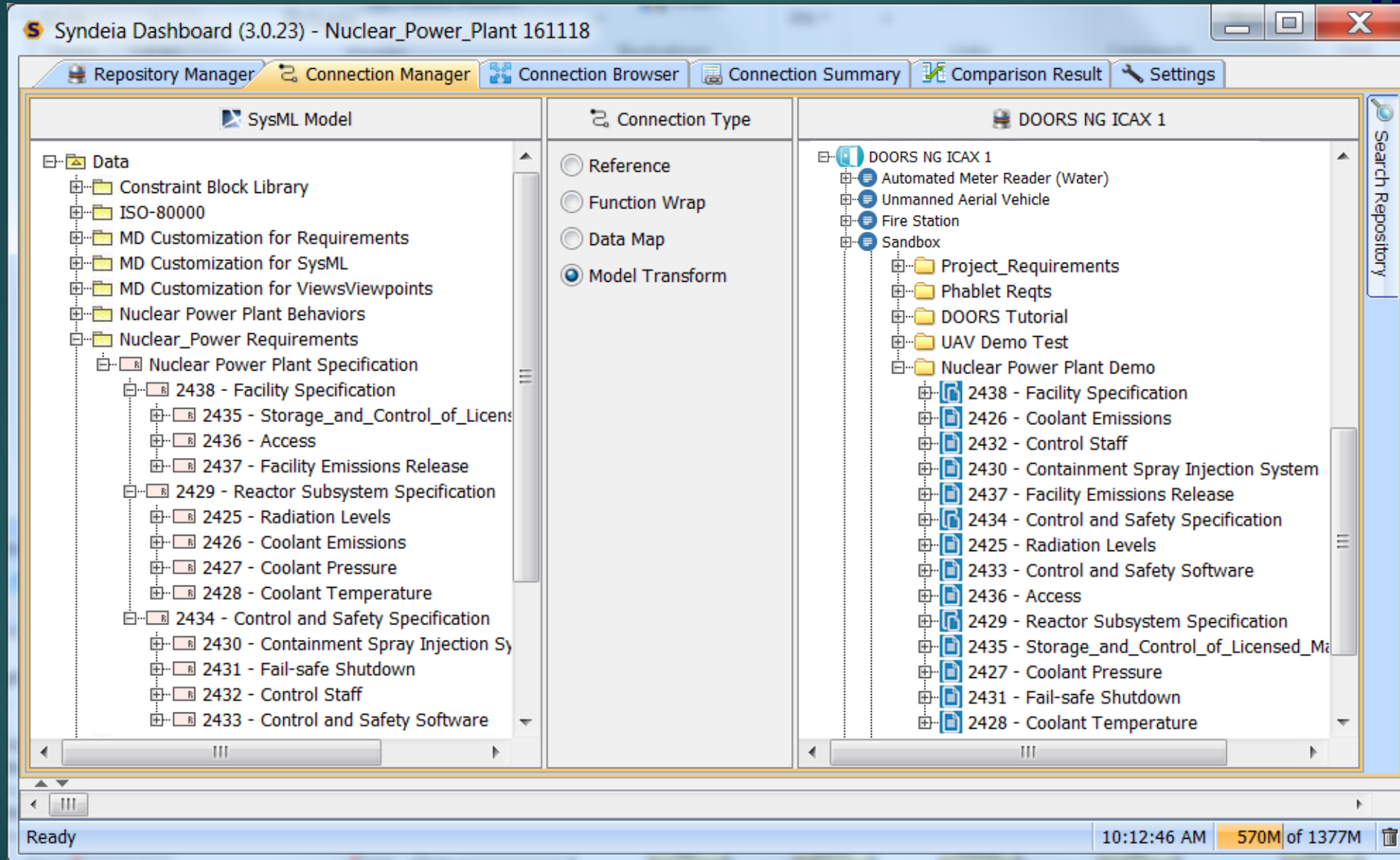
Building the Graph

- POPULATING THE SYSML MODEL FROM EXTERNAL TOOLS
- ADDING RELATIONSHIPS WITHIN THE SYSML MODEL
- POPULATING EXTERNAL TOOLS FROM THE SYSML MODEL

Total System Model



Importing Requirements into SysML

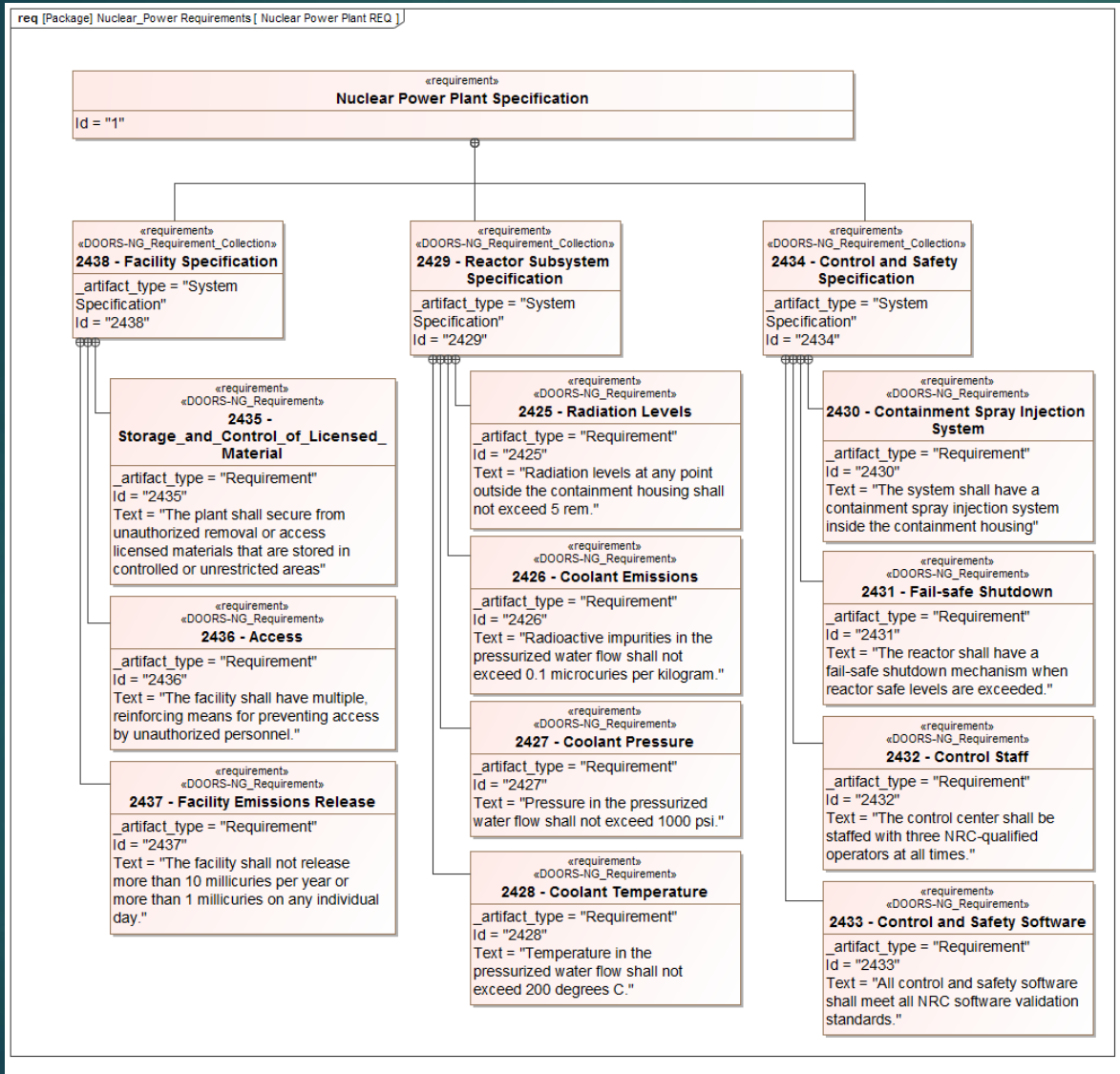


The screenshot displays the Syndeia Dashboard (3.0.23) interface for a project named "Nuclear_Power_Plant 161118". The interface is divided into three main panes:

- SysML Model:** A tree view showing a hierarchy of SysML models. The "Nuclear Power Plant Requirements" folder is expanded, showing sub-requirements such as "2438 - Facility Specification", "2429 - Reactor Subsystem Specification", and "2434 - Control and Safety Specification".
- Connection Type:** A central pane with radio buttons for selecting the connection type. The "Model Transform" option is selected.
- DOORS NG ICAX 1:** A tree view showing a hierarchy of DOORS requirements. The "Nuclear Power Plant Demo" folder is expanded, showing requirements like "2438 - Facility Specification", "2426 - Coolant Emissions", and "2429 - Reactor Subsystem Specification".

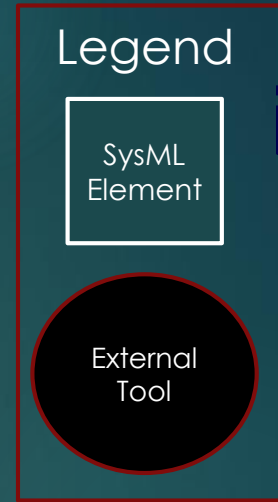
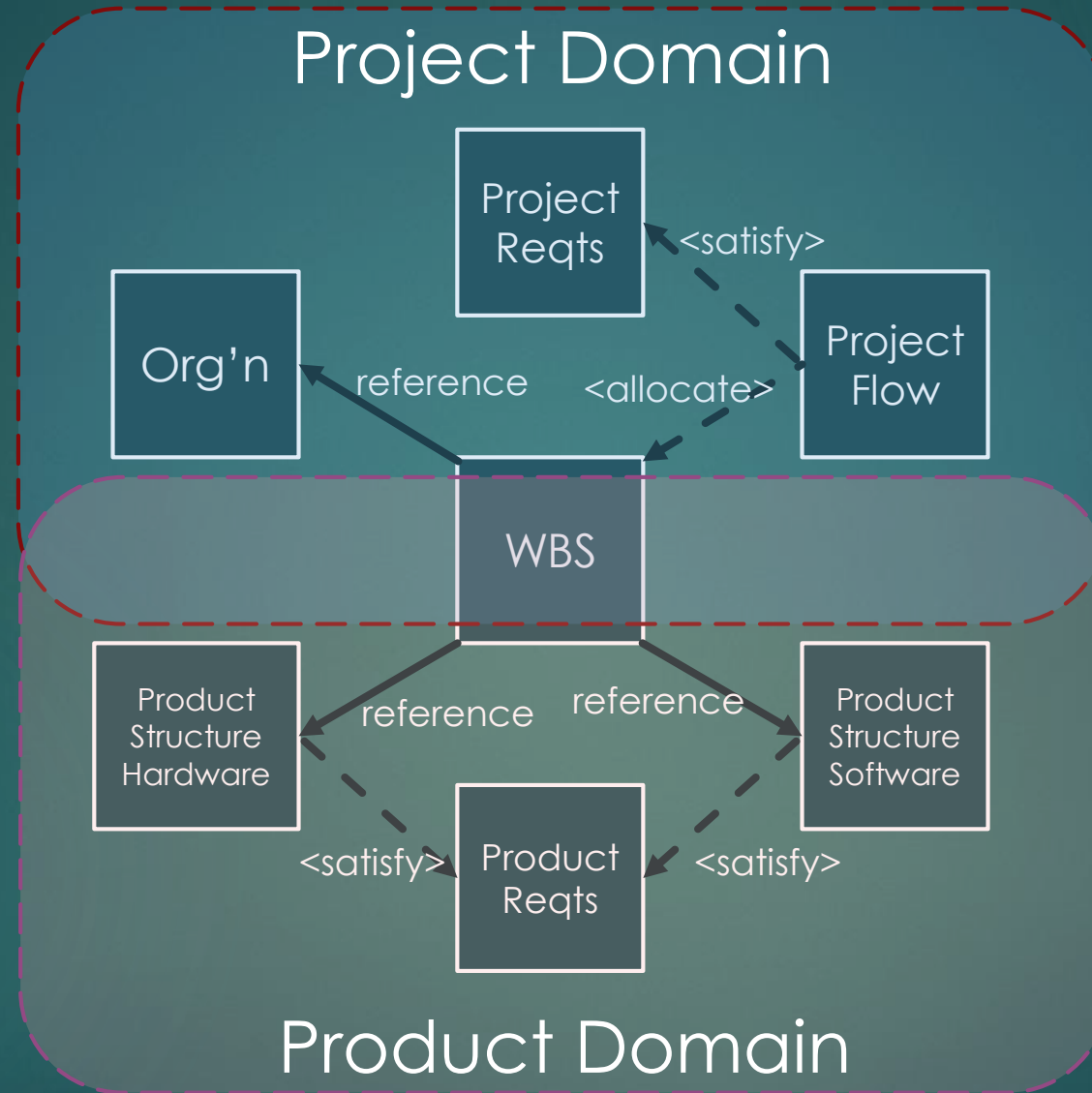
The status bar at the bottom indicates the system is "Ready", the time is 10:12:46 AM, and the memory usage is 570M of 1377M.

Importing Requirements into SysML



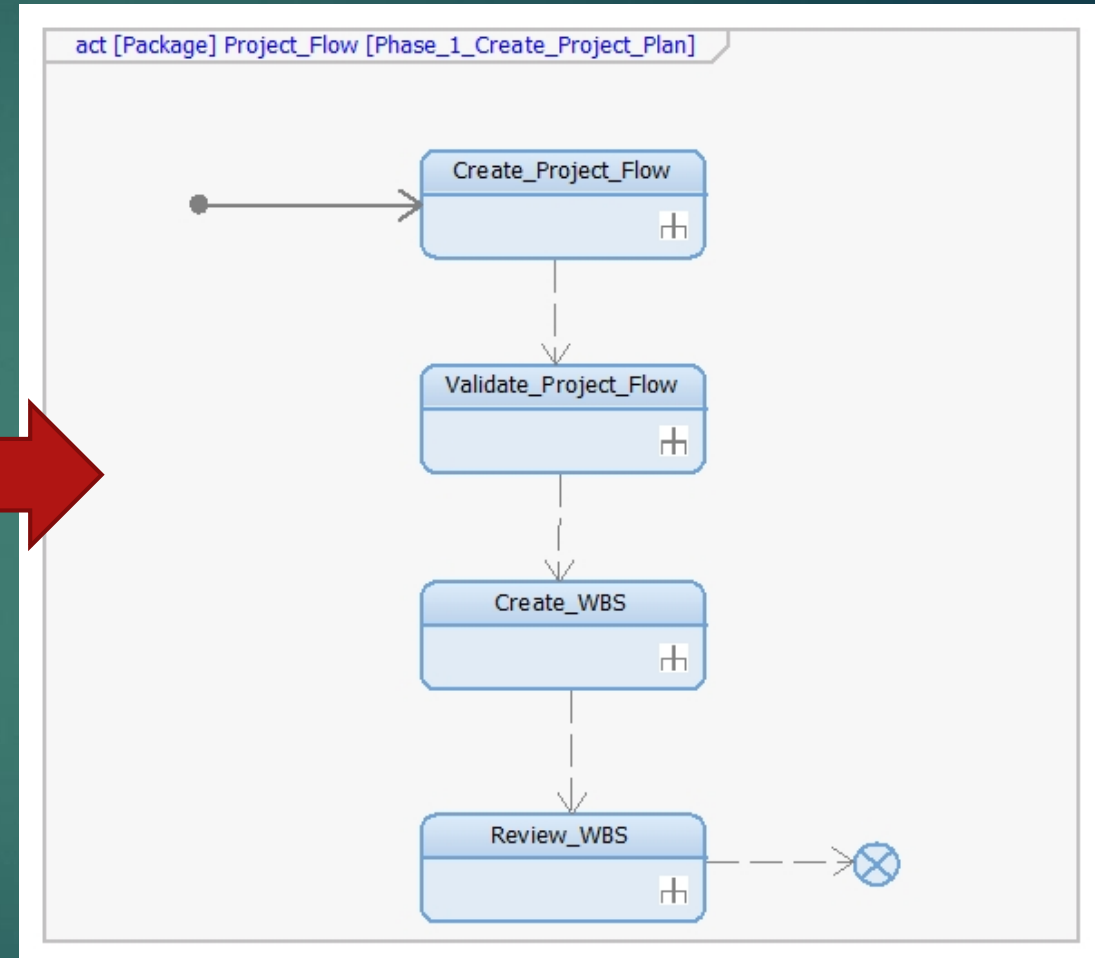
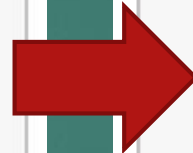
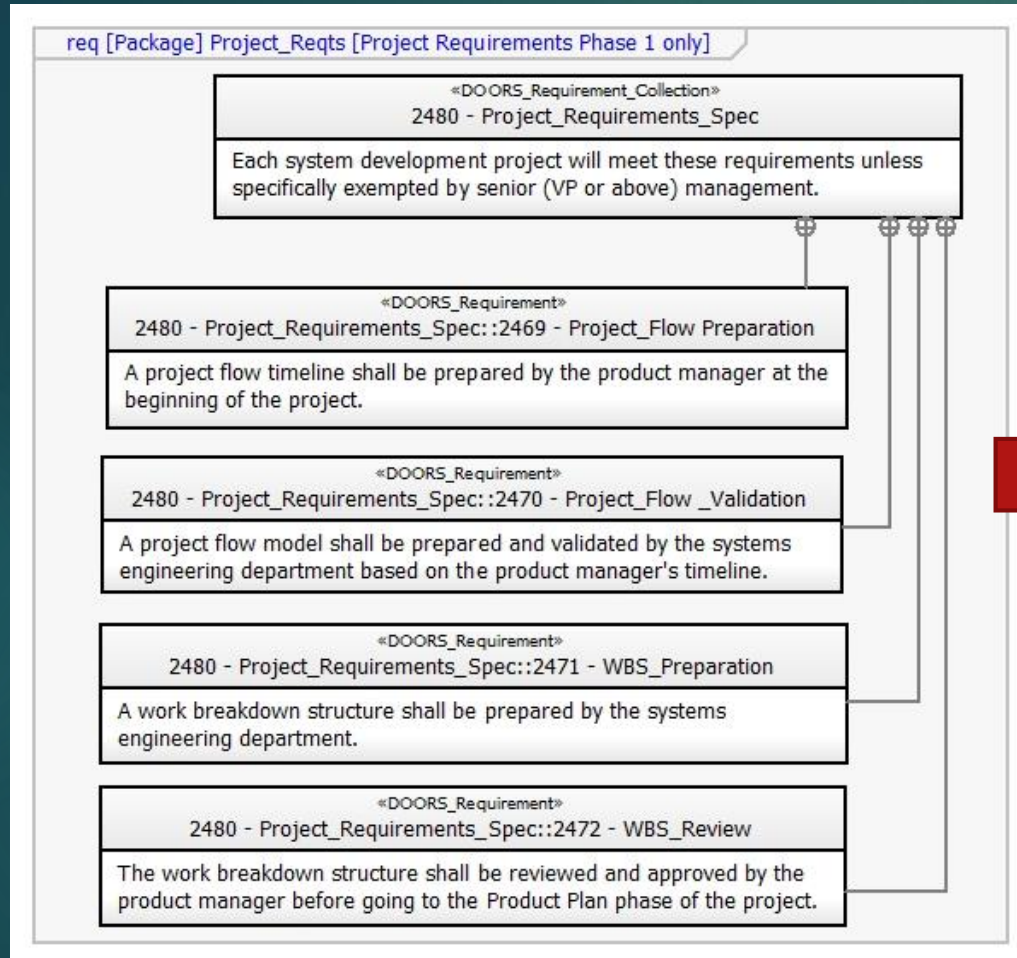


Building the SysML model



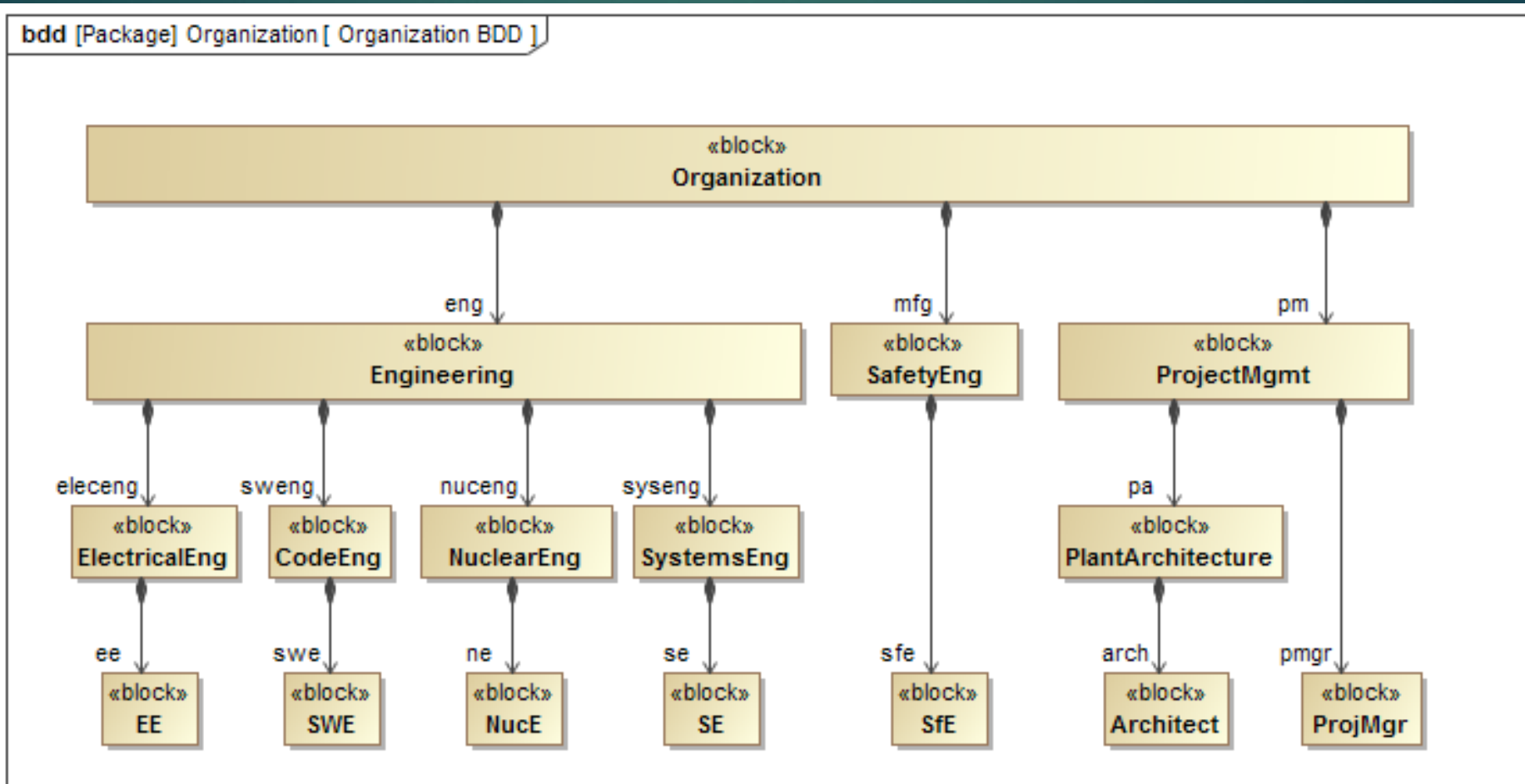


Project Requirements into Process Flows



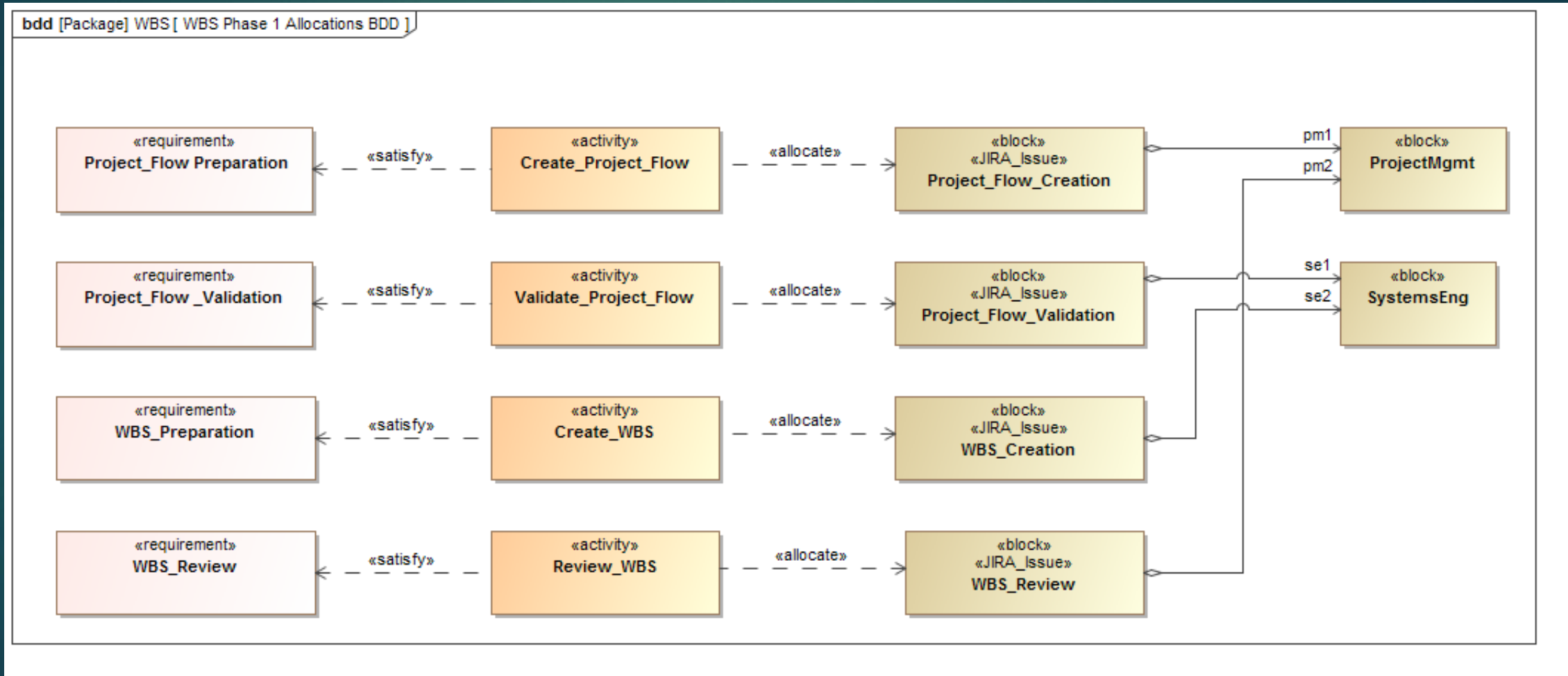


Modeling the Project Organization



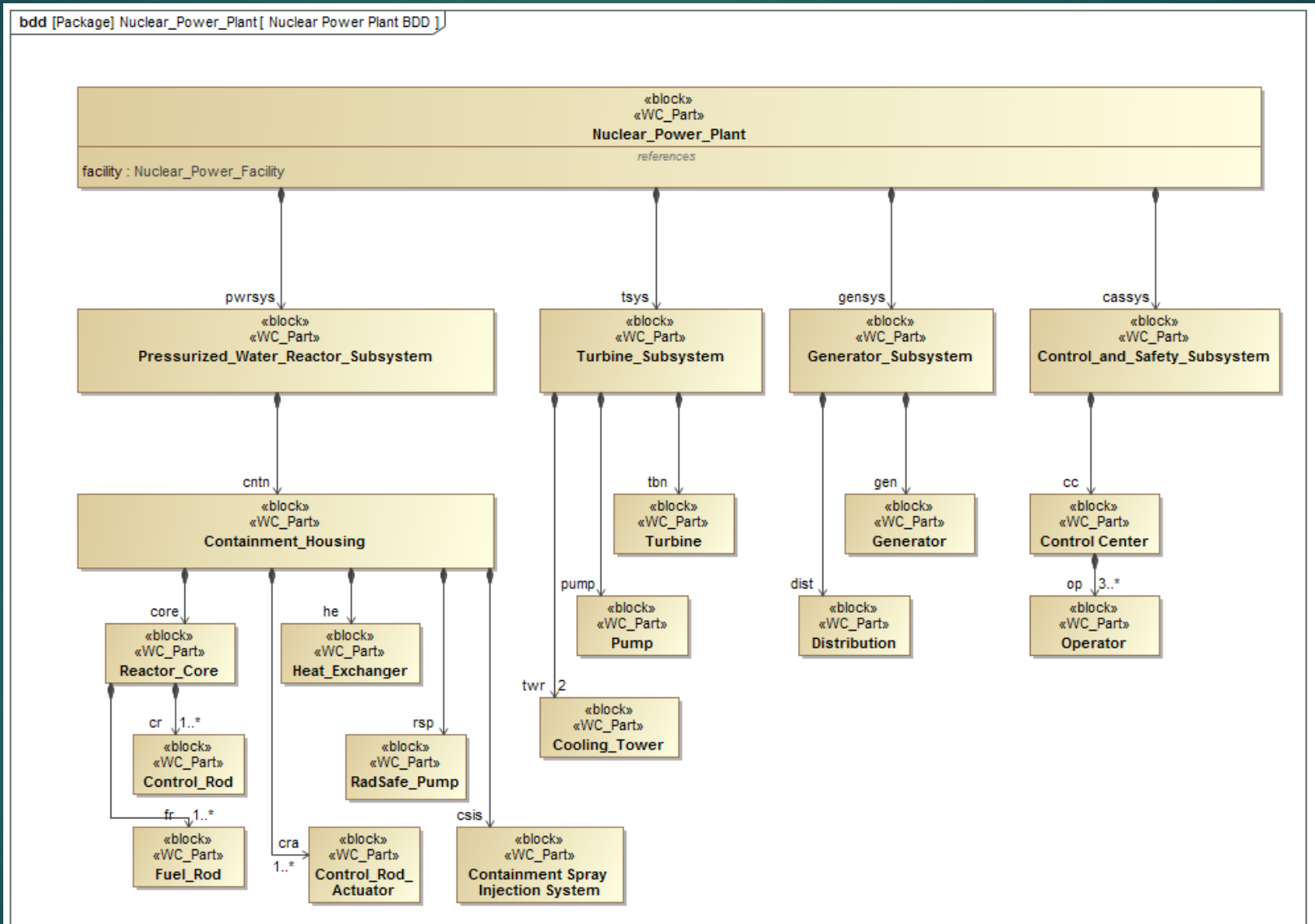


Linking Project Requirements, Processes, Tasks and Organization

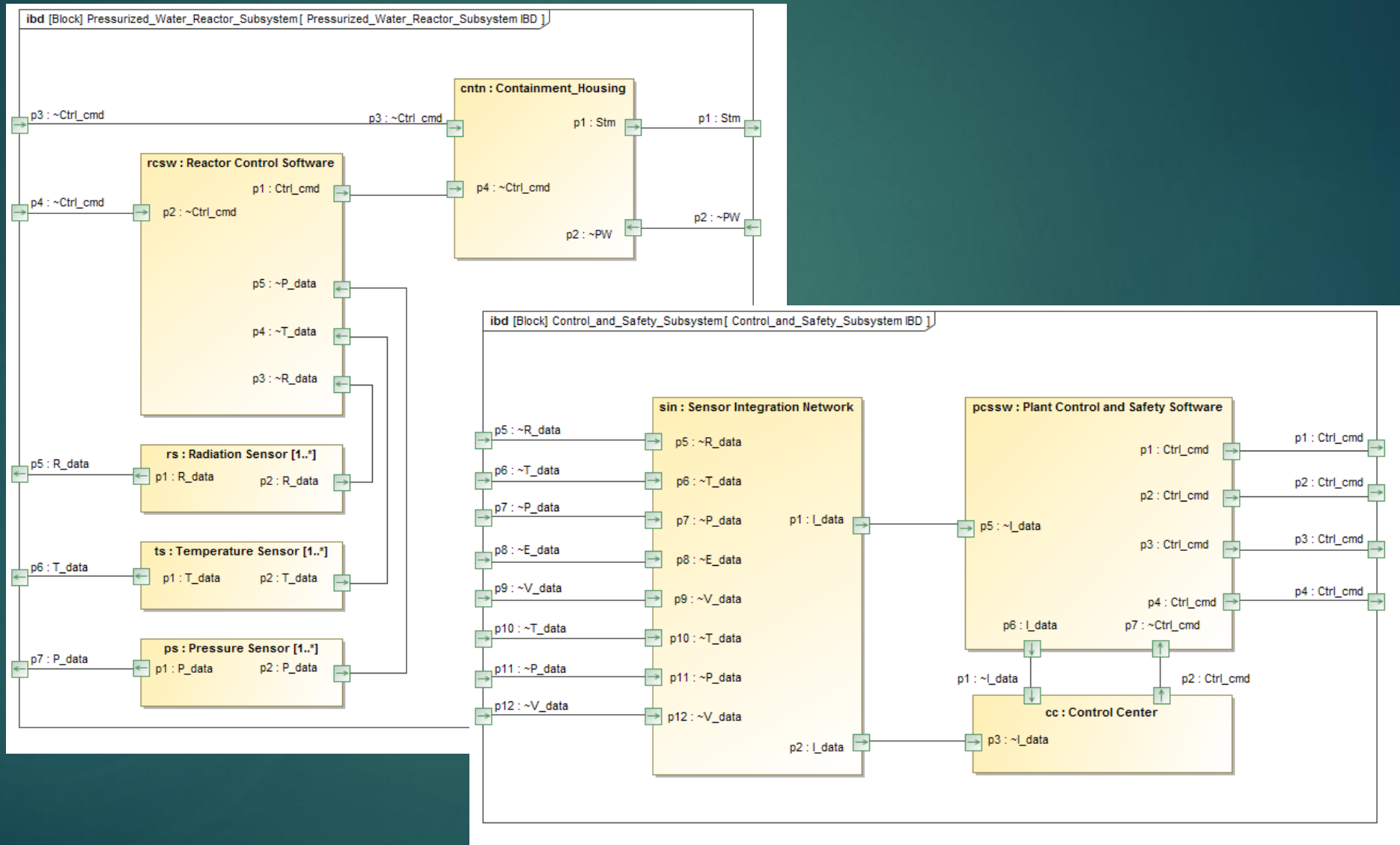




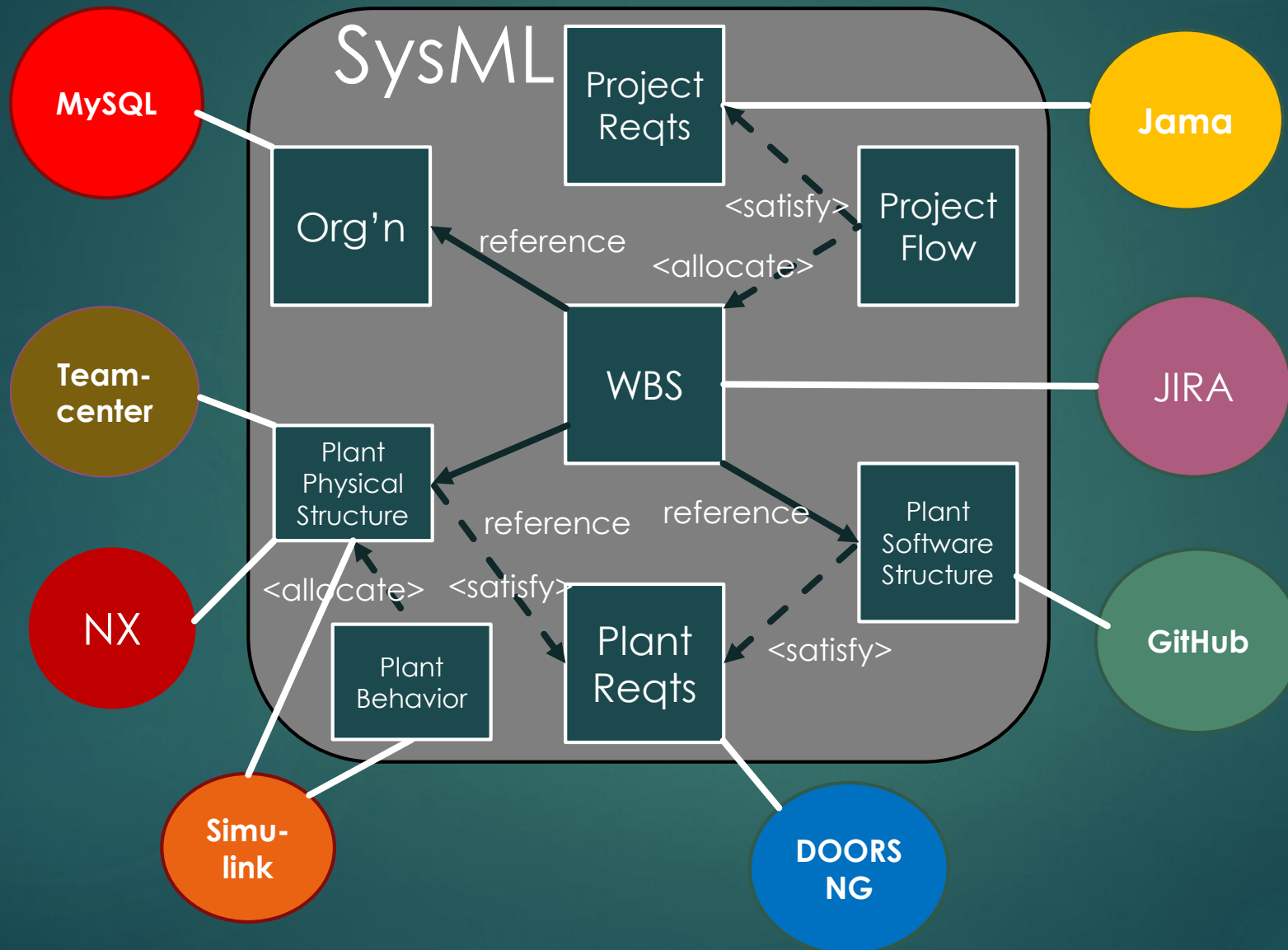
Modeling the Power Plant Structure



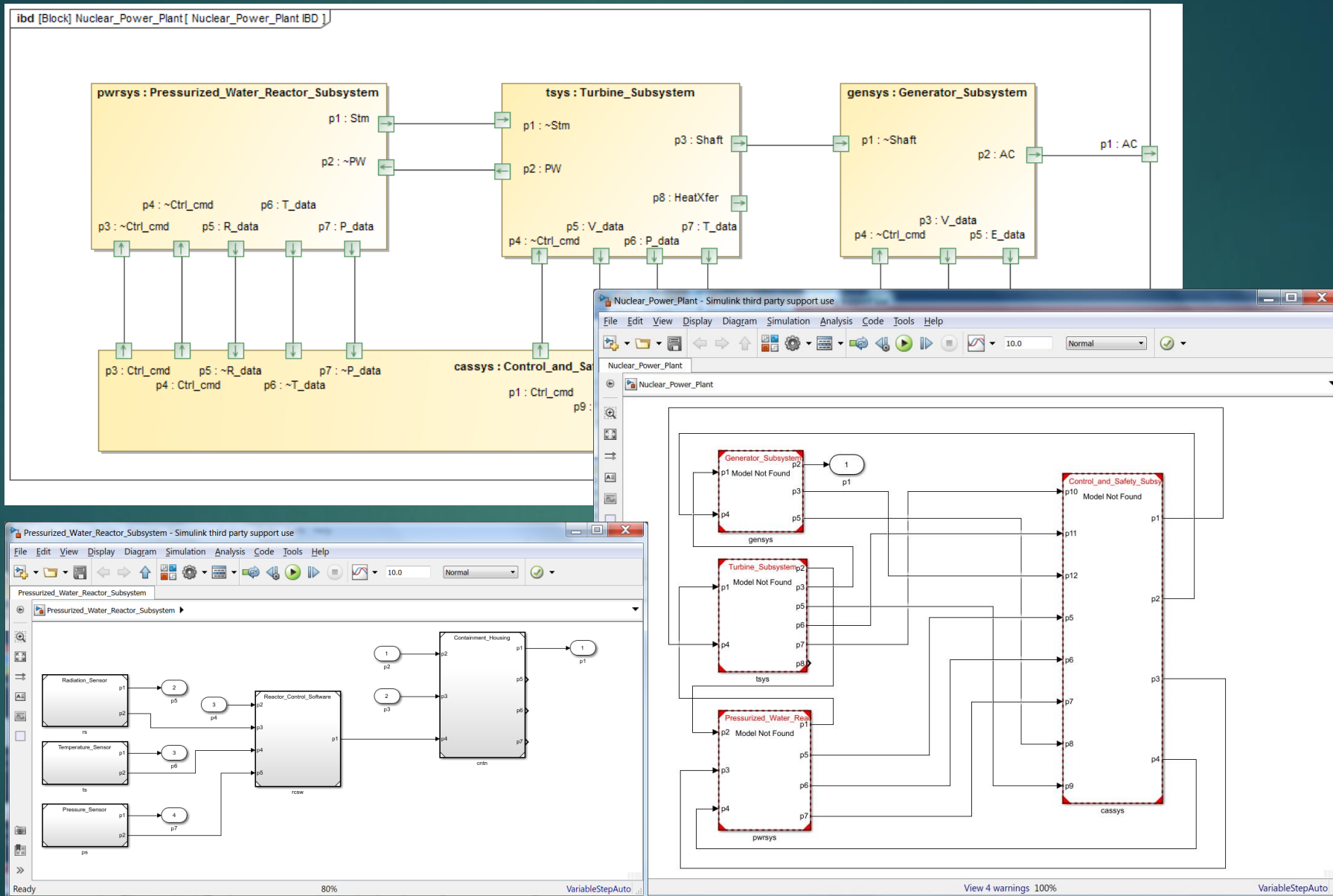
Modeling Power Plant Interfaces



Total System Model



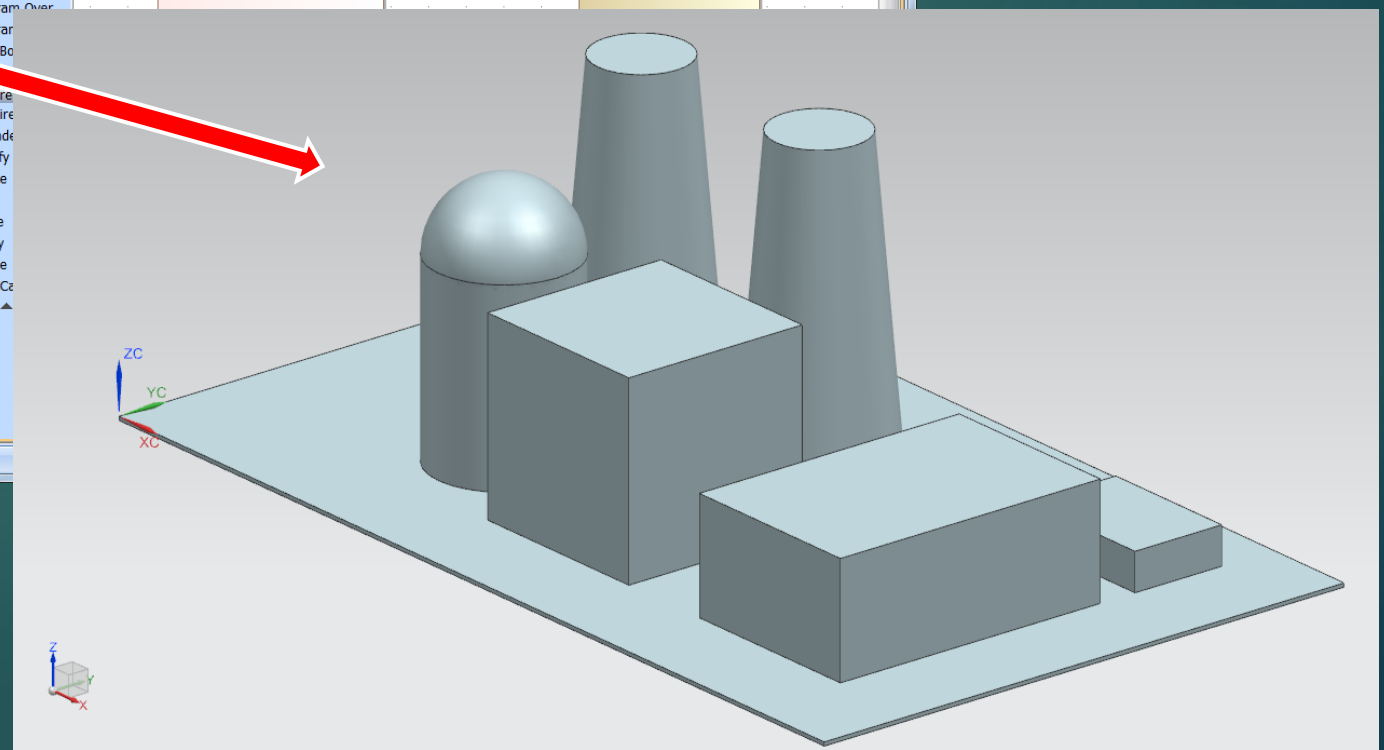
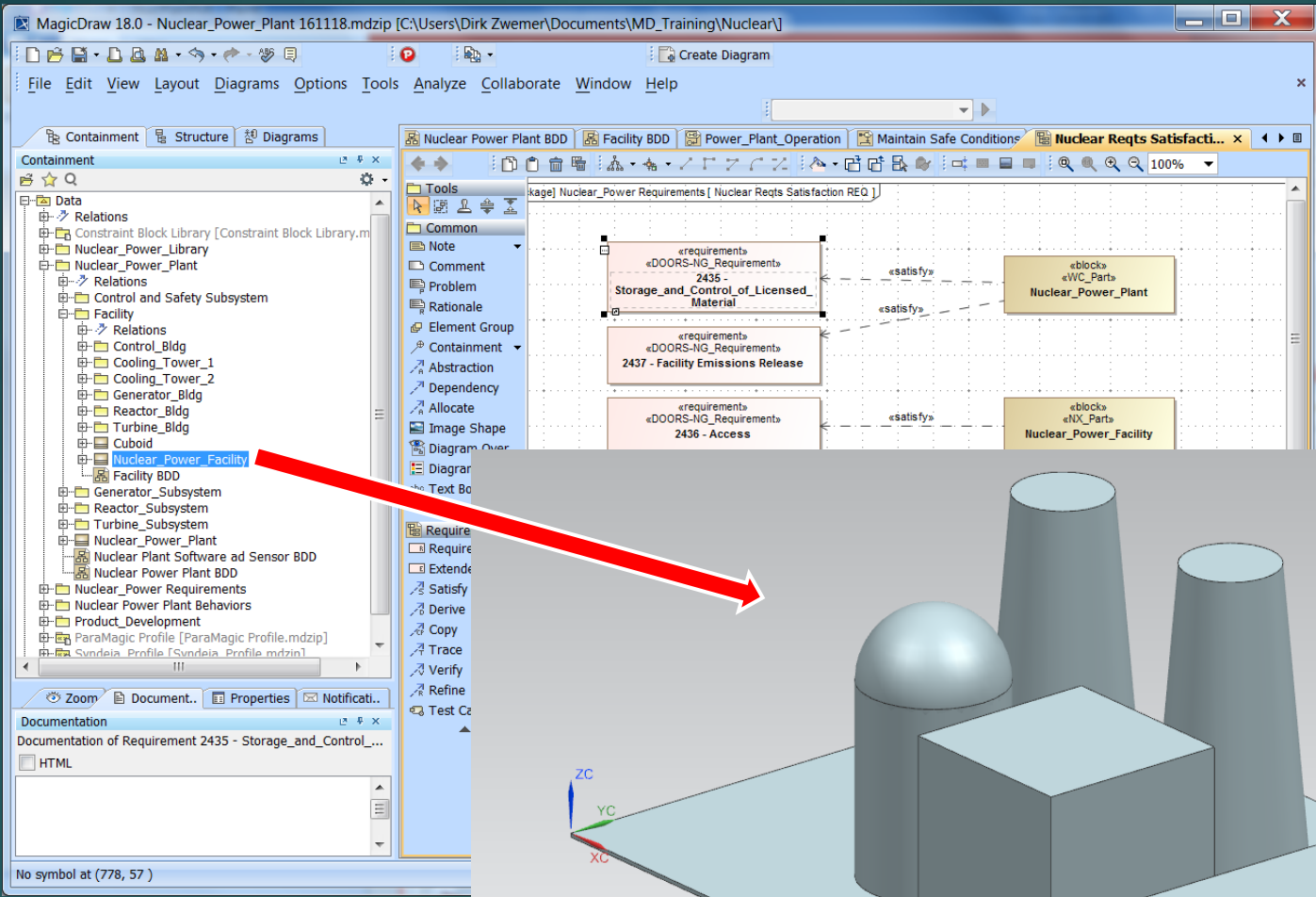
Linking Power Plant Architecture and Simulation



Using the Graph

- ACCESSING EXTERNAL DATA THROUGH THE SYSML MODEL
- COMPARING AND SYNCHRONIZING BETWEEN SYSML AND EXTERNAL DATA

Accessing CAD Files through the SysML Model





Accessing Project Management Issues

The image displays two overlapping windows. The left window is MagicDraw 18.0, showing a project management diagram with a tree view on the left and a central diagram area. The tree view includes a 'WBS_Review' block. A red arrow points from this block to the right window. The right window is the JIRA issue page for 'Syndeia Demo Box / SDB-322 WBS_Review'. The issue details are as follows:

Field	Value
Type	Improvement
Status	OPEN
Priority	Major
Resolution	Unresolved
Labels	None

The JIRA page also shows the assignee as Dirk Zwemer, the reporter as Dirk Zwemer, and the issue was created and updated 2 hours ago. There are no comments on this issue.



Comparing Linked Requirements in SysML and DOORS NG

Specification of Requirement 2437 - Facility Emissions Release

Specification of Requirement properties
Specify properties of the selected Requirement in the properties specification table. Choose the Expert or All options from the Properties drop-down list to see more properties.

2437 - Facility Emissions Release Properties: Expert

- Requirement
 - Satisfies
 - Name: 2437 - Facility Emissions Release
 - Id: 2437
 - Text: The facility shall not release more than 15 millicuries per year or more than 1 millicuries on any individual day.
 - Applied Stereotype: Requirement [Class] [SysML::Requirements] ↔ DOORS-NG_Requirement [Class] [Syndeia_Prof]
 - Source: Nuclear_Power Requirements::Nuclear Power Plant
 - Qualified Name: Nuclear_Power Requirements::Nuclear Power Plant
 - Verify Method:
 - Risk:
 - Traceability
 - Owner: 2438 2438 - Facility Specification [Nuclear_P...
 - Refines:
 - Traced From: Nuclear_Power_Plant [Nuclear_Power_Plant]
 - Derived:
 - Refined By:
 - Traced To:
 - Verified By:
 - Derived From:
 - Satisfied By: Nuclear_Power_Plant [Nuclear_Power_Plant]
 - Text: The textual representation or a reference to the textual representation of the requirement.

Syndeia Dashboard (3.0.23) - Nuclear_Power_Plant 161118

Repository Manager | Connection Manager | Connection Browser | Connection Summary | Comparison Result | Settings

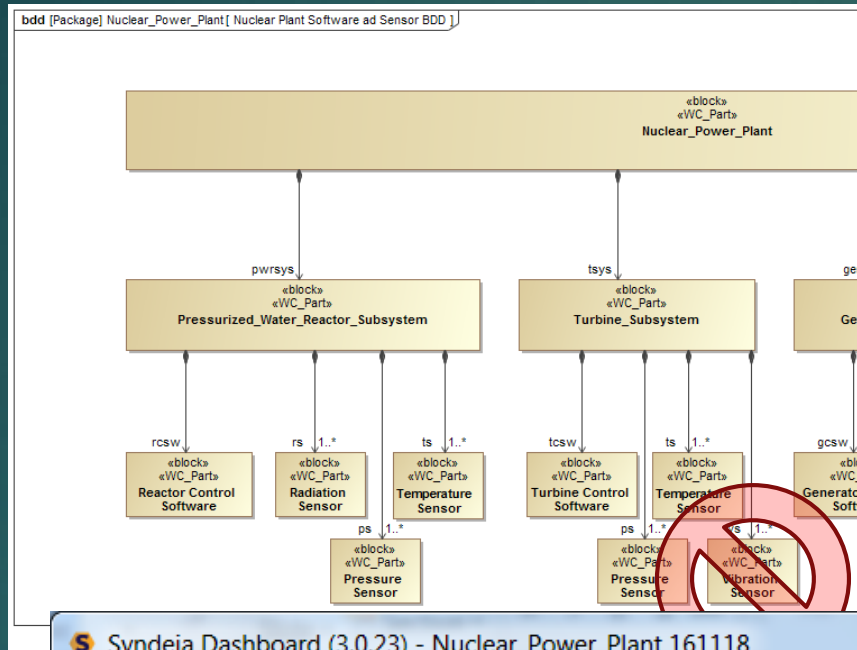
Q- Type here to filter connections

Conn ID	Source	Latest Target	Comment
bb56917...	2438 - Facility Specification <ul style="list-style-type: none">- artifact type (System Specificat...- id (2438)- name (2438 - Facility Specificat...- text ()	2438 - Facility Specification <ul style="list-style-type: none">- artifact type (System Specification)- id (2438)- name (2438 - Facility Specification)- description ()	The SysML requirement "2438 - Facility Specification" is conn... DOORS-NG artifact type is same for both SysML requirement ... IDs of SysML requirement "2438 - Facility Specification" and D...
439c7b3...	2435 - Storage_and_Control_of_L...	2435 - Storage_and_Control_of_Licen...	SysML requirement "2435 - Storage_and_Control_of_Licensed...
9c9666a...	2436 - Access	2436 - Access	SysML requirement "2436 - Access" and DOORS-NG requirem...
3056065...	2437 - Facility Emissions Release	2437 - Facility Emissions Release	SysML requirement "2437 - Facility Emissions Release" and D...
9c9666a...	2436 - Access <ul style="list-style-type: none">- artifact type (Requirement)- children [0]- id (2436)- name (2436 - Access)- text (The facility shall have mul...	2436 - Access <ul style="list-style-type: none">- artifact type (Requirement)- children [0]- id (2436)- name (2436 - Access)- description (The facility shall have ...	The SysML requirement "2436 - Access" is connected to the l... DOORS-NG artifact type is same for both SysML requirement ... SysML requirement and DOORS-NG requirement have the sa... IDs of SysML requirement "2436 - Access" and DOORS-NG Re...
439c7b3...	2435 - Storage_and_Control_of_L...	2435 - Storage_and_Control_of_Licen...	The SysML requirement "2435 - Storage_and_Control_of_Lice...
3056065...	2437 - Facility Emissions Release <ul style="list-style-type: none">- artifact type (Requirement)- children [0]- id (2437)- name (2437 - Facility Emission...- text (The facility shall not relea...	2437 - Facility Emissions Release <ul style="list-style-type: none">- artifact type (Requirement)- children [0]- id (2437)- name (2437 - Facility Emissions Rel...- description (The facility shall not rel...	The SysML requirement "2437 - Facility Emissions Release" is... DOORS-NG artifact type is same for both SysML requirement ... SysML requirement and DOORS-NG requirement have the sa... IDs of SysML requirement "2437 - Facility Emissions Release" ... Names of SysML requirement "2437 - Facility Emissions Relea...

Comparing Structure in SysML and PLM



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Syndeia Dashboard (3.0.23) - Nuclear_Power_Plant 161118

Repository Manager Connection Manager Connection Browser Connection Summary

Q- Type here to filter connections

Source (SysML Element)	Name	Type
Turbine_Subsystem		
Relations		
Cooling_Tower		
Pump		
Turbine		
Turbine_Control_Software		
Turbine_Subsystem		

[Nuclear_Power_Plant::Tur... BLOCK_SIMULINK_MOD
ant::Tur... BLOCK_WC_PART_MO

Expand All
Collapse All
Refresh
Go to...
Open Target
Compare SysML & Target
Sync SysML -> Target
Sync Target -> SysML
Delete Connection(s)

Syndeia Dashboard (3.0.23) - Nuclear_Power_Plant 161118

Repository Manager Connection Manager Connection Browser Connection Summary **Comparison Result** Settings

Q- Type here to filter connections

Clear Export to Excel

Conn ID	Source	Target	Latest Target	Comment
afb9f7c...	Turbine_Subsystem	Turbine_Subsystem (A...	Turbine_Subsystem (A...	The block Turbine_Subsystem is connected to Windchill part Tur...
	ps : Pressure Sensor	ps : Pressure Sensor (...	ps : Pressure Sensor (...	Part property ps and part occurrence ps have the same names a...
	pump : Pump	pump : Pump (A.1)	pump : Pump (A.1)	Part property pump and part occurrence pump have the same n...
	tbn : Turbine	tbn : Turbine (A.1)	tbn : Turbine (A.1)	Part property tbn and part occurrence tbn have the same names...
	tscsw : Turbine Control...	tscsw : Turbine Control...	tscsw : Turbine Control...	Part property tscsw and part occurrence tscsw have the same na...
	ts : Temperature Sensor	ts : Temperature Sens...	ts : Temperature Sens...	Part property ts and part occurrence ts have the same names a...
	twr : Cooling_Tower	twr : Cooling_Tower (...	twr : Cooling_Tower (...	Part property twr and part occurrence twr have the same name...
		vs : Vibration Sensor (...		Part occurrence in Windchill has no corresponding part property ...

Ready 12:59:16 PM 551M of 1057M

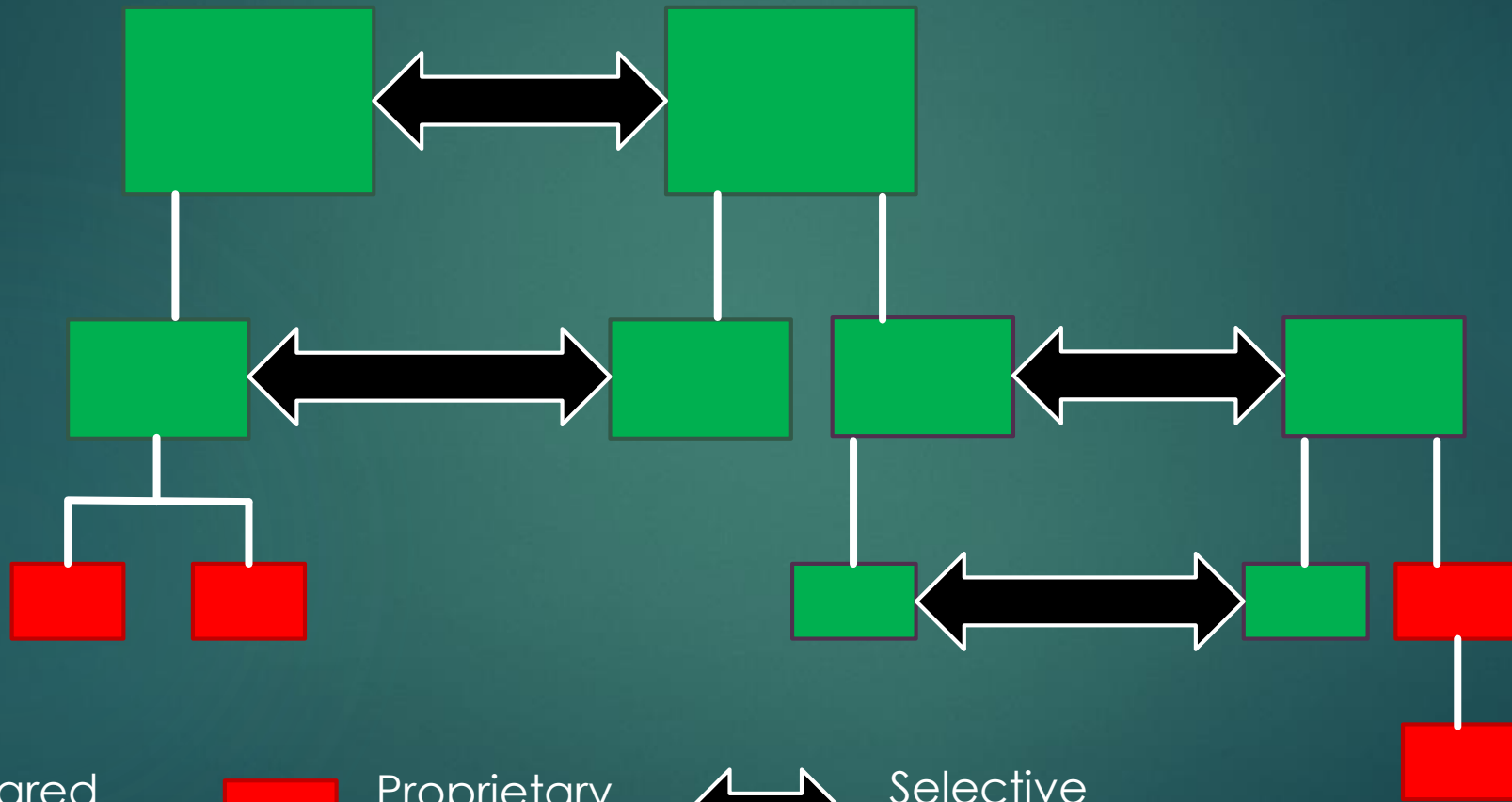


How can linked models protect proprietary data? **intercax**

Prime's Model

Shared Model

Subcontractor's Model



 Shared Data

 Proprietary Data

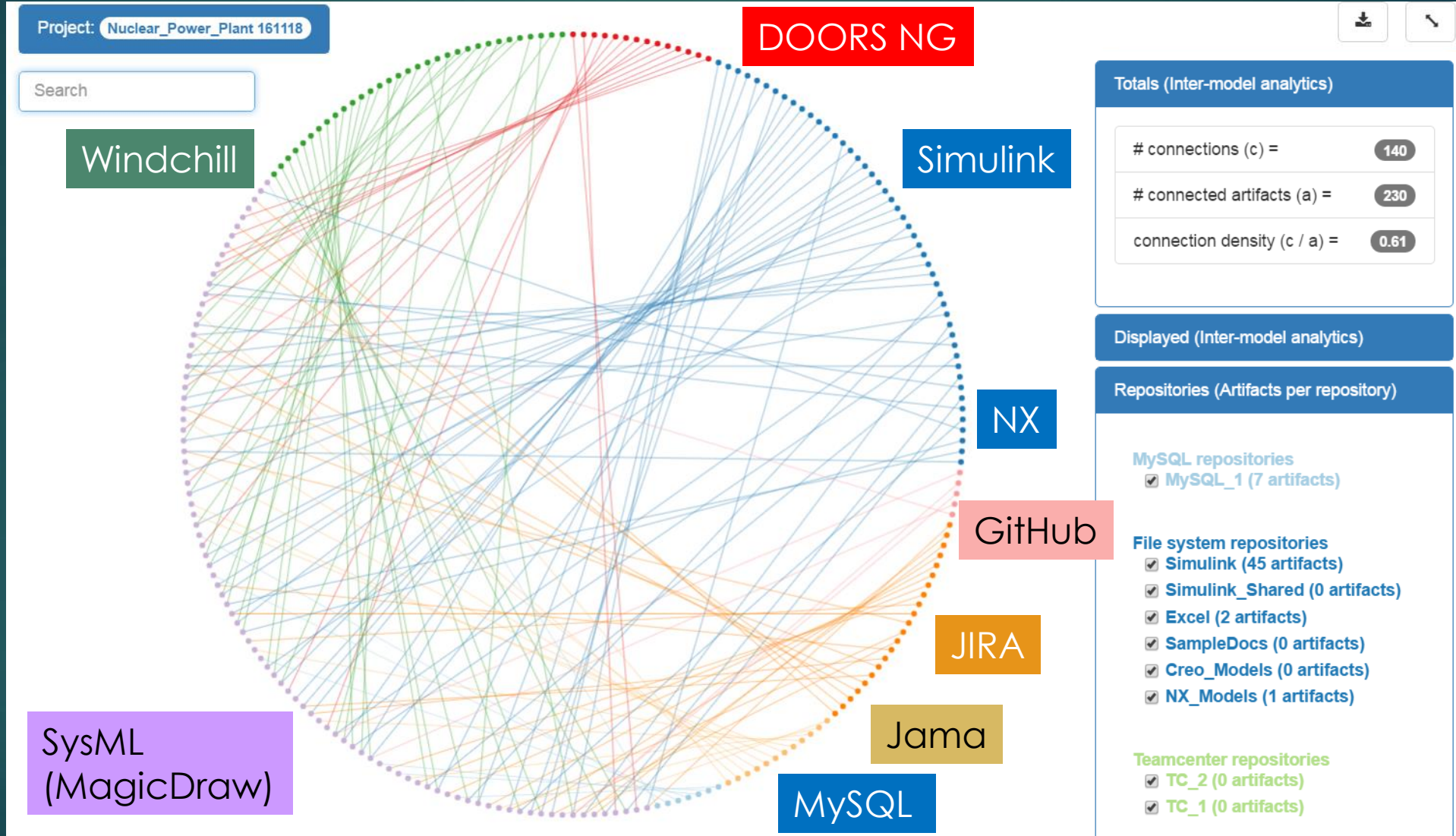
 Selective Synchs

Querying the Graph

- VISUALIZING THE INTERMODEL CONNECTIONS
- VISUALIZING EXTENDED CHAINS
- QUERYING THE GRAPH DATABASE (PROTOTYPE)

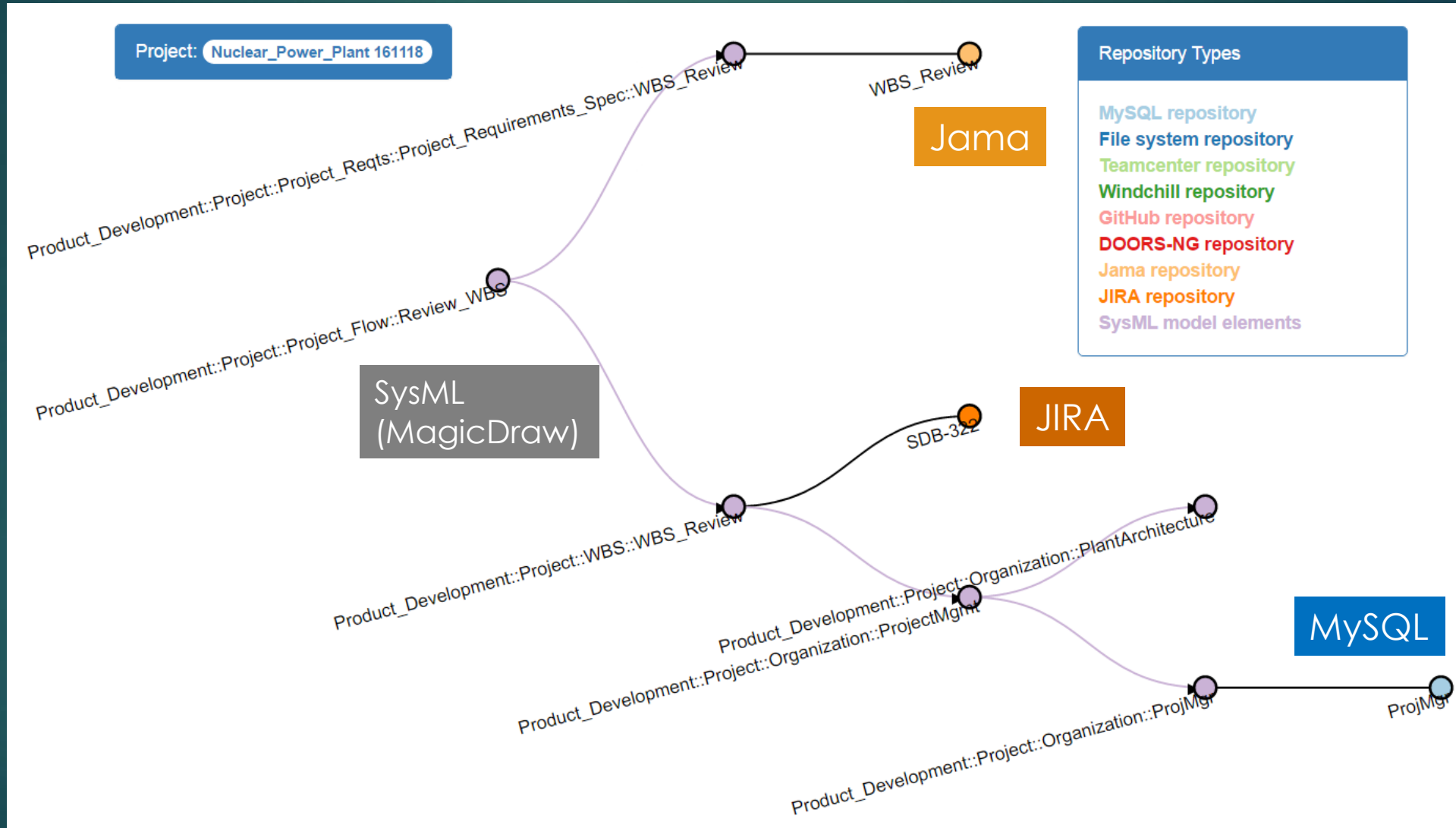


Global Visualization



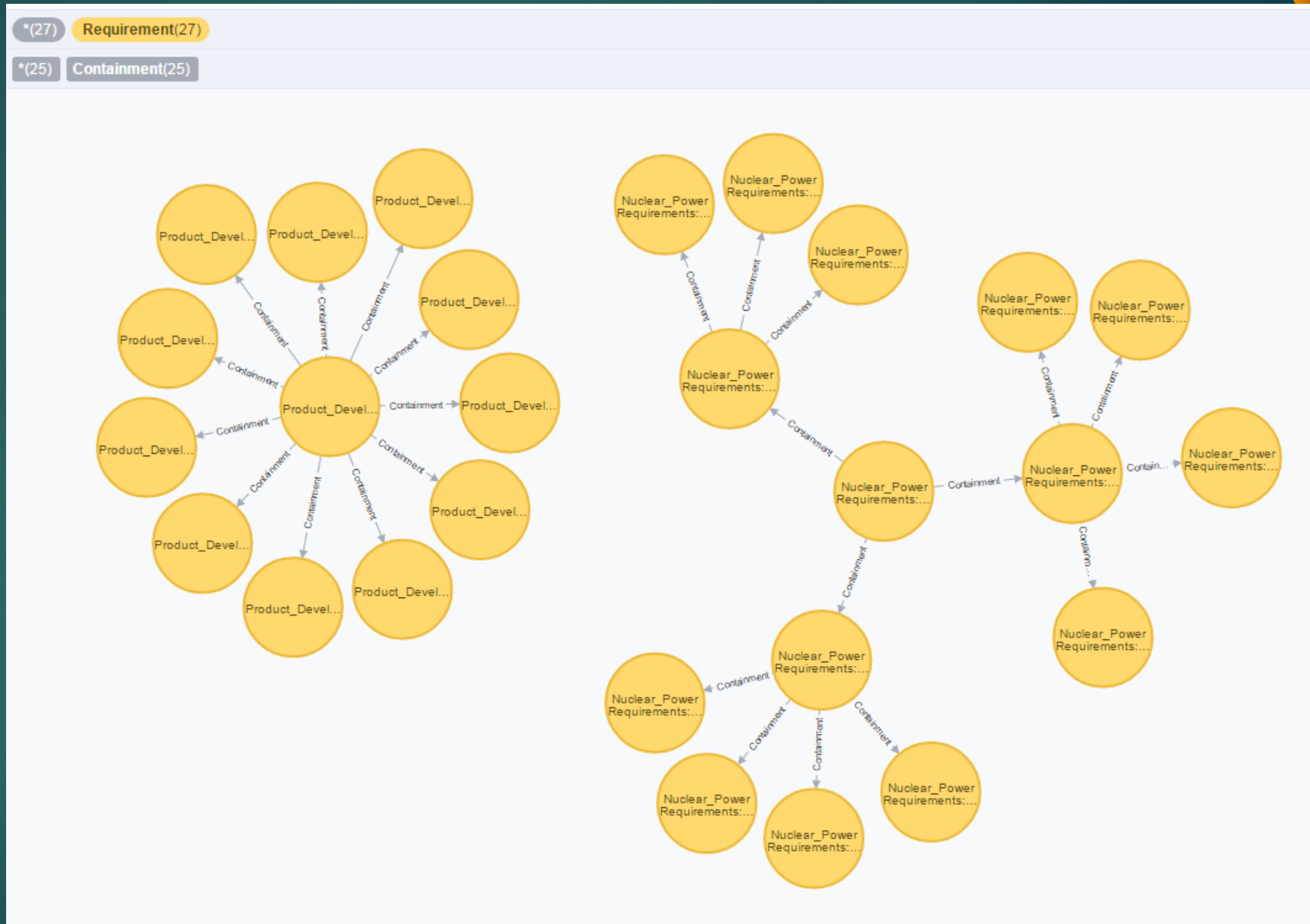


Directed Visualization





Query: Show me all the SysML requirements



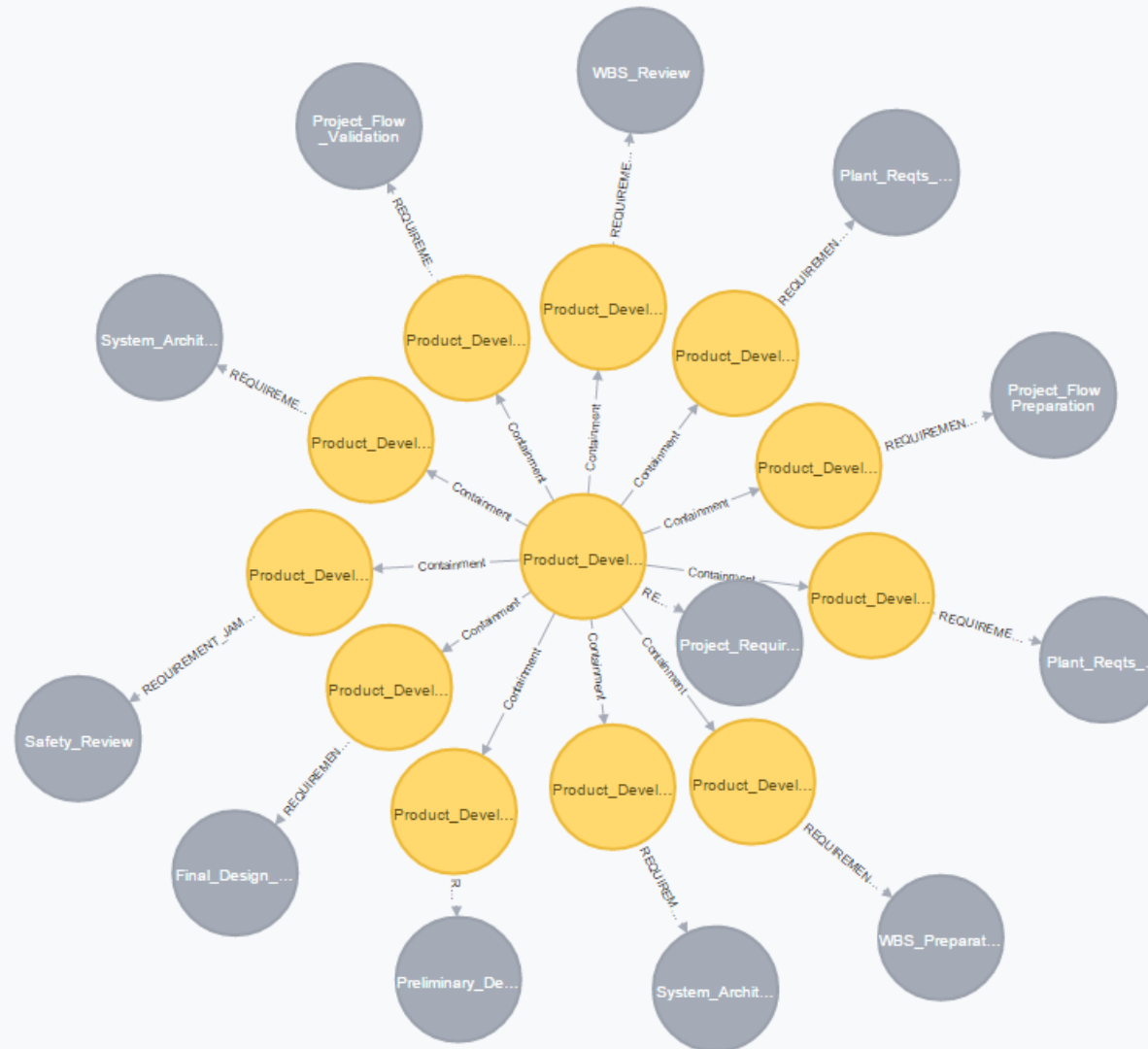


Query: Show me all the SysML requirements connected to Jama requirements

```
$ match (n:Requirement)-[]->(j:Jama_requirement) return n,j
```

*(24) Jama_requirement(12) Requirement(12)

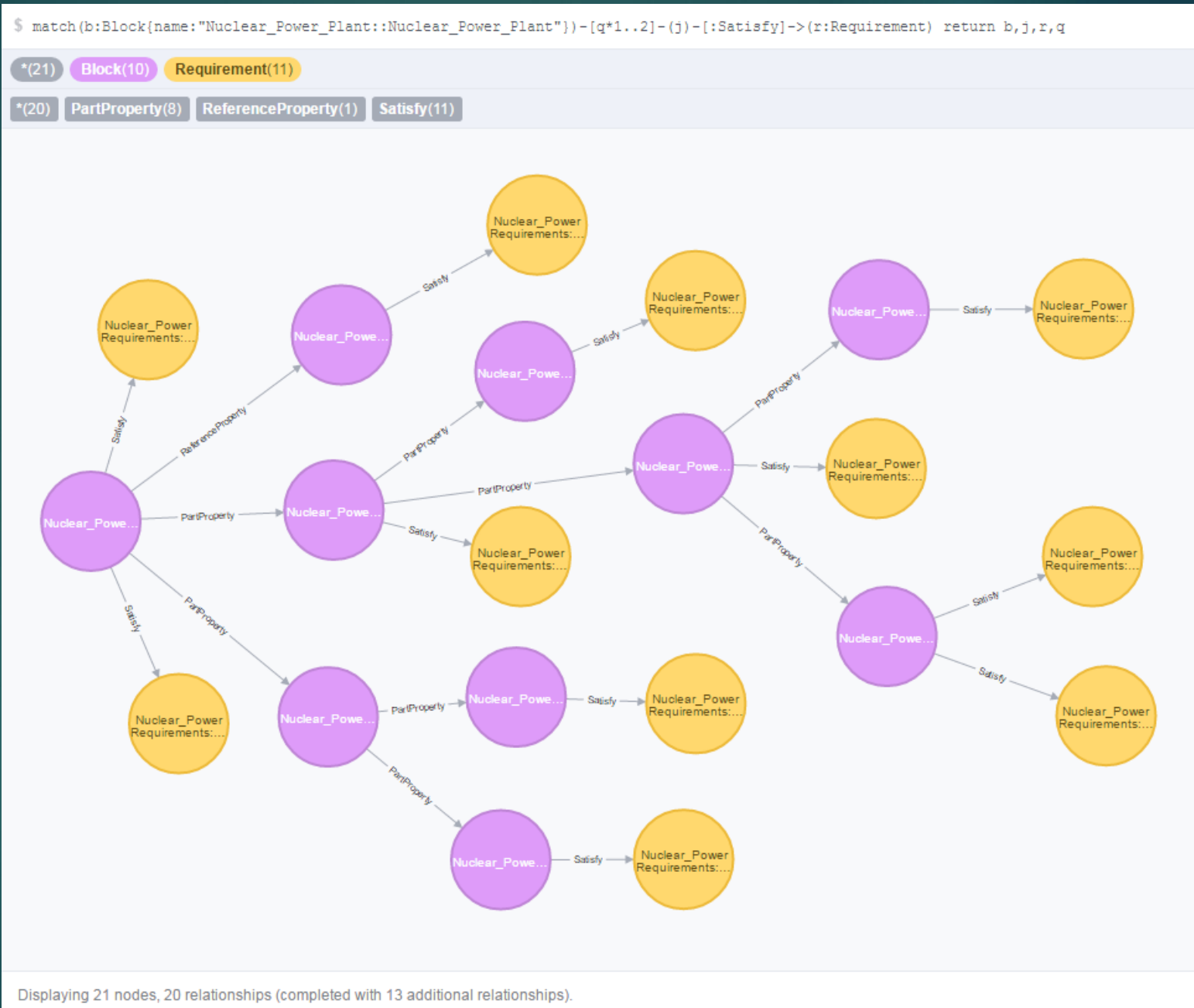
*(23) Containment(11) REQUIREMENT_JAMA_MODEL_TRANSFORM_CONNECTION(12)



Displaying 24 nodes, 23 relationships (completed with 23 additional relationships).



Query: Show me all the SysML requirements the Nuclear Power Plant block or its parts must satisfy directly



Query: Show me all the SysML blocks affected by Fail-Safe Shutdown requirement

```
$ match (r:Requirement{name:"Nuclear_Power Requirements::Nuclear Power Plant Specification::Control and Safety Specification::Fail-safe Shutdown"})<-[:Satisfy]-(im)<-[x:PartProperty|ReferencePropert...
```

r	b
<p>sysml_id _18_0_5_17d10425_1466947640830_4189_14608</p> <p>name Nuclear_Power Requirements::Nuclear Power Plant Specification::Control and Safety Specification::Fail-safe Shutdown</p>	<p>sysml_id _18_0_5_17d10425_1466948151445_158775_1674</p> <p>name Nuclear_Power_Plant::Reactor_Subsystem::Reactor Control Software</p>
<p>sysml_id _18_0_5_17d10425_1466947640830_4189_14608</p> <p>name Nuclear_Power Requirements::Nuclear Power Plant Specification::Control and Safety Specification::Fail-safe Shutdown</p>	<p>sysml_id _18_0_5_17d10425_1466902708046_205920_1291</p> <p>name Nuclear_Power_Plant::Reactor_Subsystem::Pressurized_Water_Reactor_Subsystem</p>
<p>sysml_id _18_0_5_17d10425_1466947640830_4189_14608</p> <p>name Nuclear_Power Requirements::Nuclear Power Plant Specification::Control and Safety Specification::Fail-safe Shutdown</p>	<p>sysml_id _18_0_5_17d10425_1466882985191_969107_1277</p> <p>name Nuclear_Power_Plant::Nuclear_Power_Plant</p>

Returned 3 rows in 35 ms.

* (4) Block (3) Requirement (1)

* (3) PartProperty (2) Satisfy (1)



```

graph TD
    R((Nuclear_Power Requirements...))
    B1((Nuclear_Powe...))
    B2((Nuclear_Powe...))
    B3((Nuclear_Powe...))
    R -- Satisfy --> B1
    B2 -- PartProperty --> B1
    B3 -- PartProperty --> B2
    
```

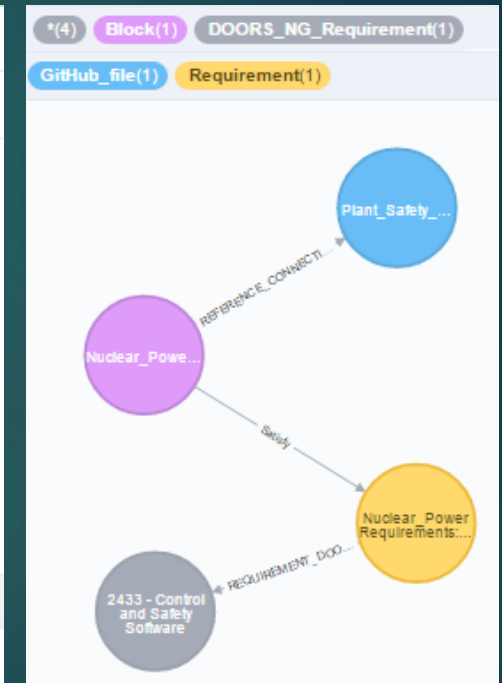


Query: Is GitHub file “Plant_Safety_Software” connected to DOORS requirement “2433 - Control and Safety Software”?

```
$ match(b:GitHub_file{name:"Plant_Safety_Software"})<-[r1]-(n)-[r2*]->(t:DOORS_NG_Requirement{name:"2433 - Control and Safety ...
```

r1	n	r2
<code>conId</code> 6f71f9e4-64f2-4b60-ae45-6db6297288c5	<code>sysml_id</code> _18_0_5_17d10425_1466948169420_108926_167 <code>name</code> Nuclear_Power_Plant::Control and Safety Subsystem::Plant Control and Safety Software	<code>sysml_id</code> _18_0_5_17d10425_1466960910923_583547_236 <code>name</code> (empty) <code>conId</code> 03ec9c30-105c-4204-a428-dca015c0c3a4

Returned 1 row in 17 ms.

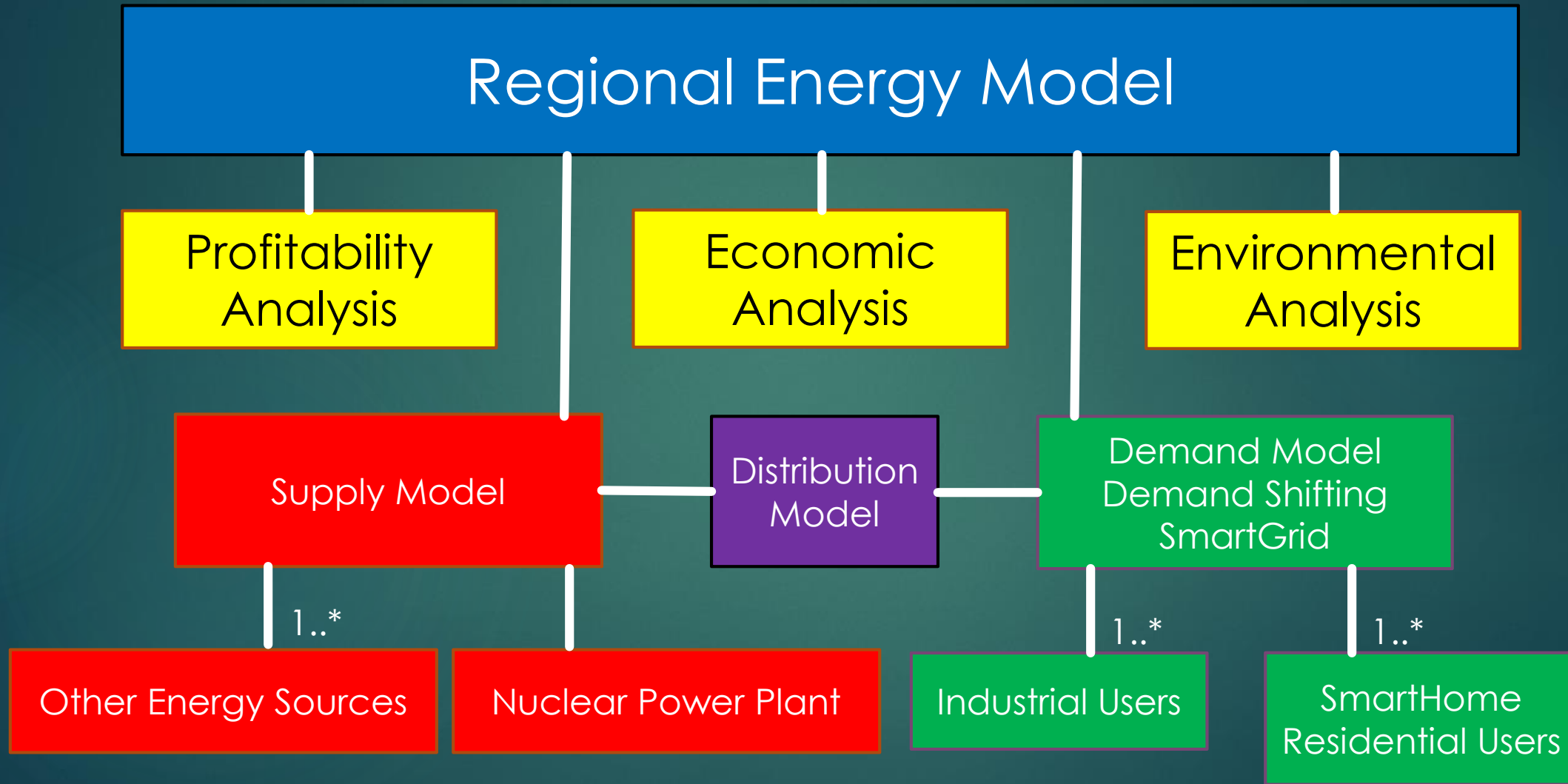


Building a Bigger Graph

- USING YOUR MODEL IN A LARGER MODEL
- PERFORMING PARAMETRIC ANALYSES

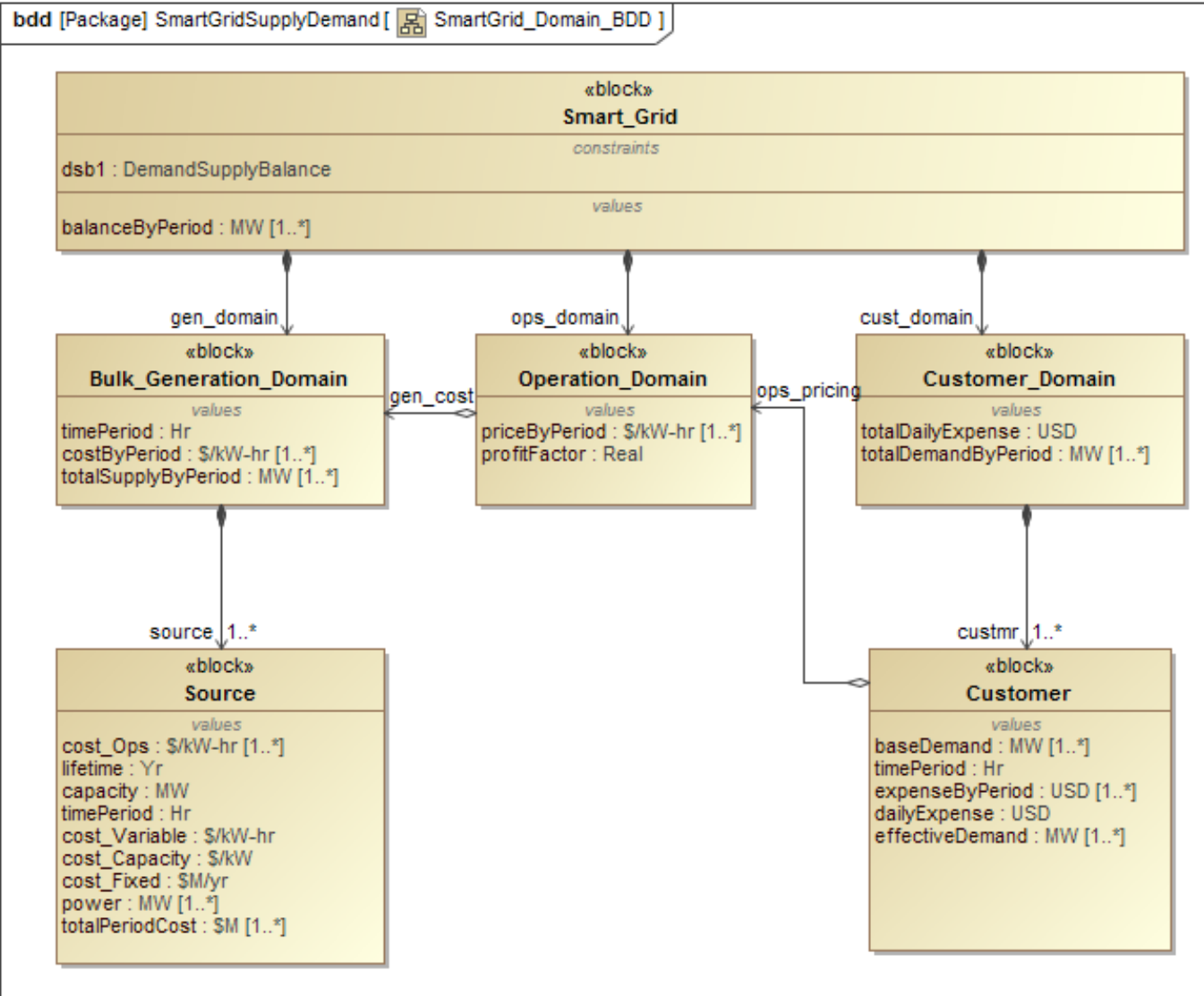


Energy System Model Integration



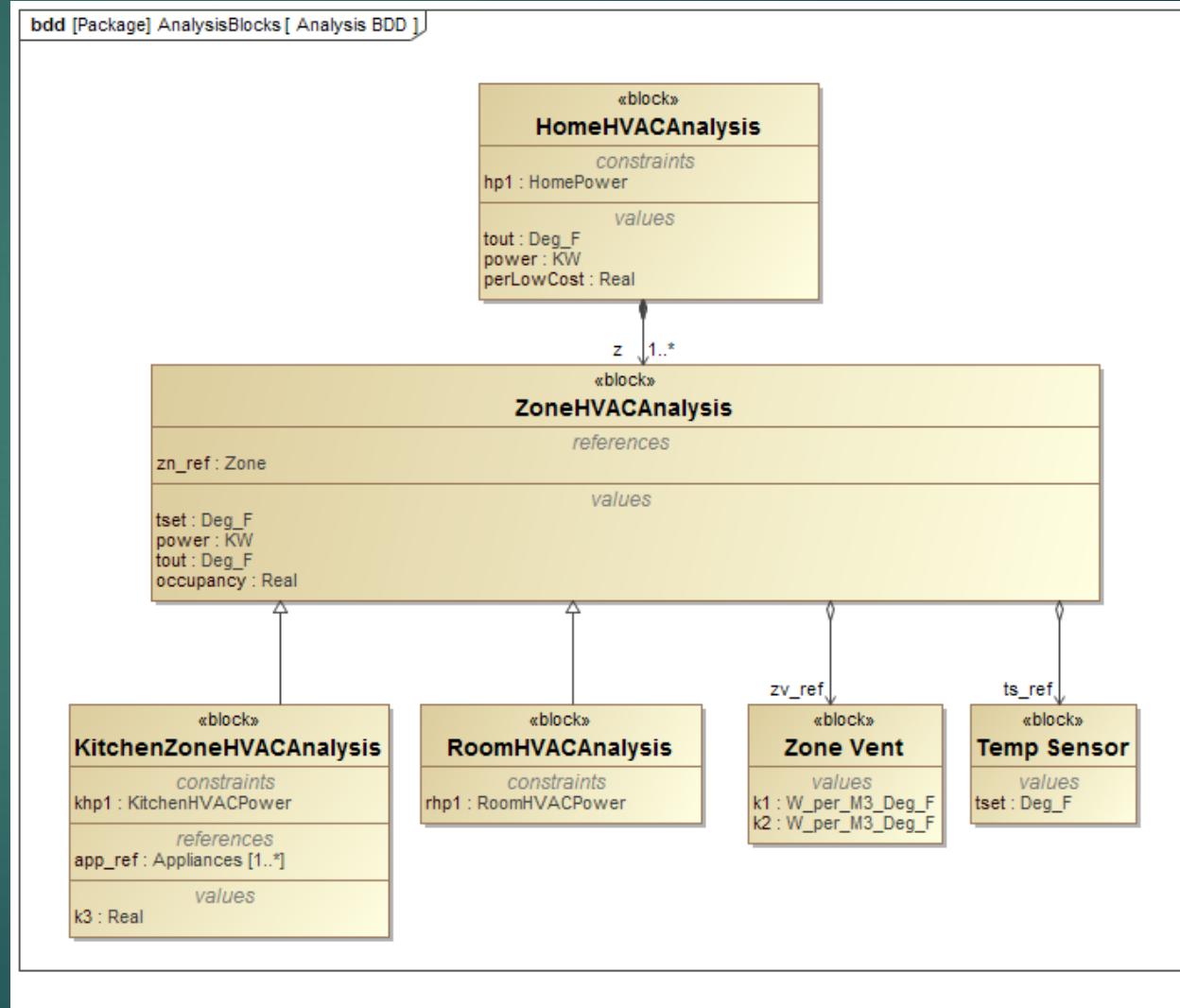
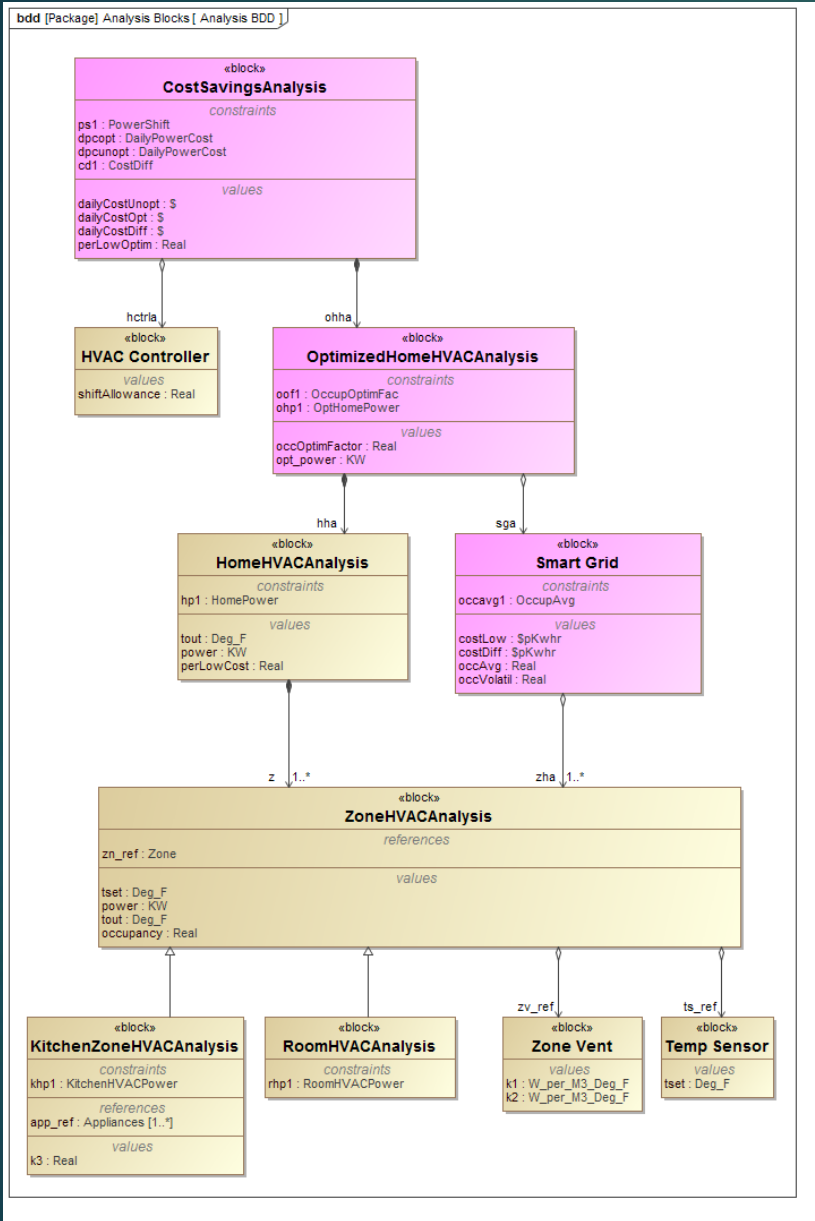


Smart Grid Model





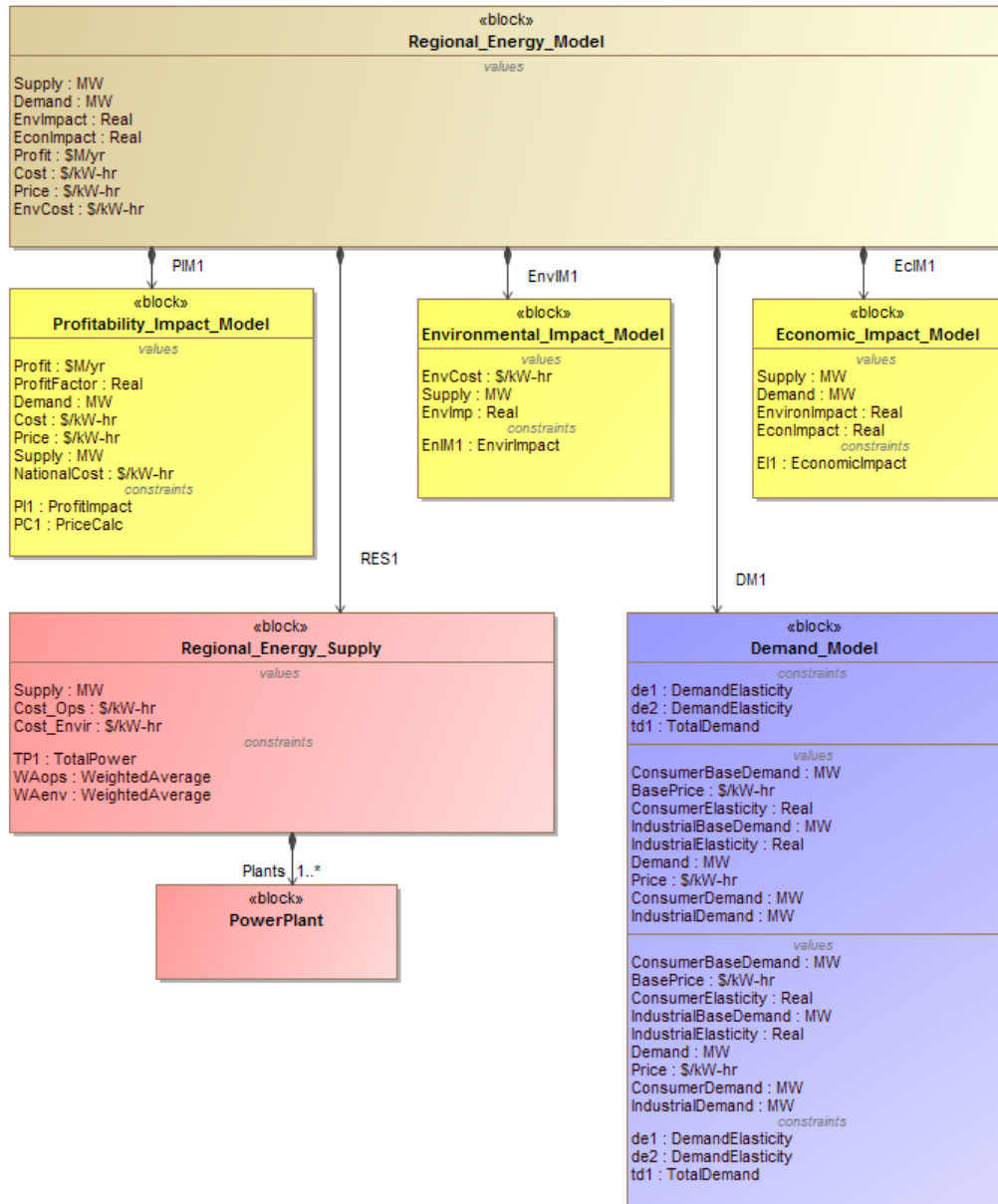
Smart Home Model



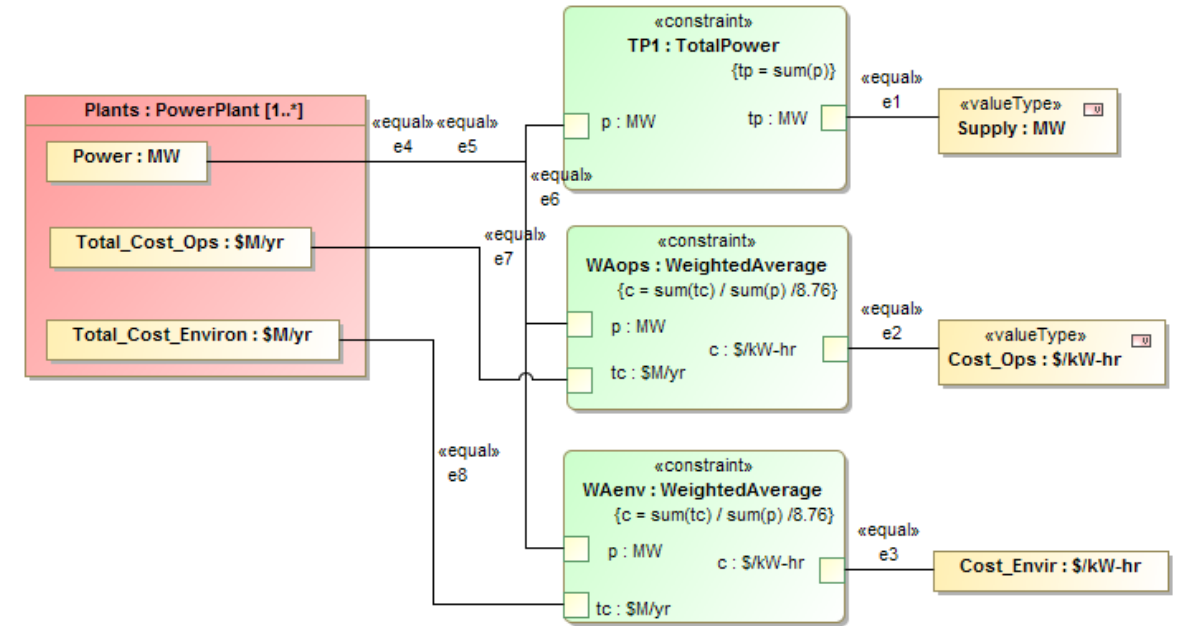


Energy System Analysis

bdd [Package] EnergySystem [RegionalEnergyBdd]

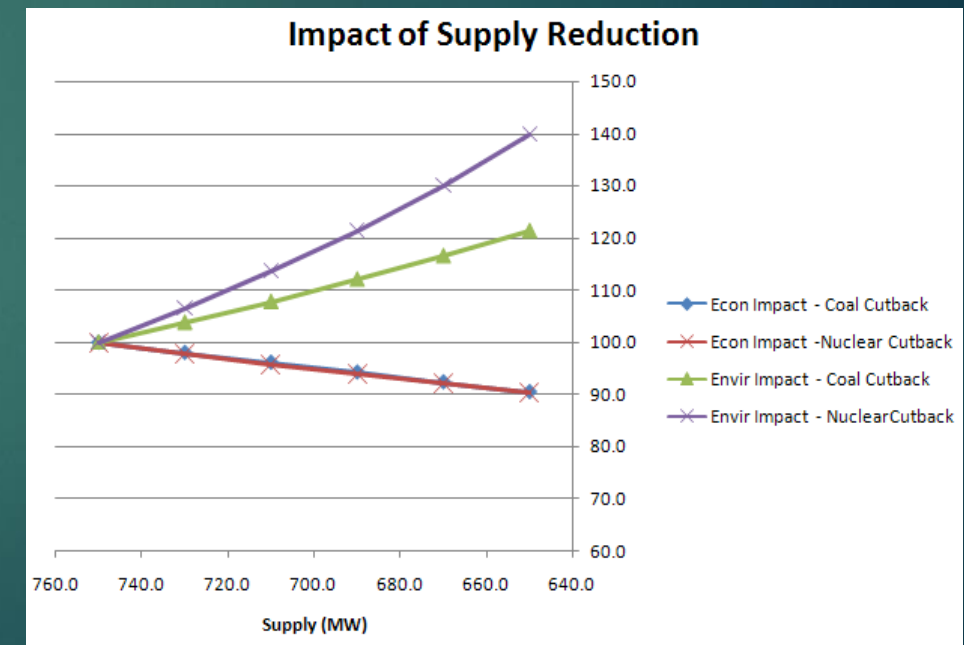
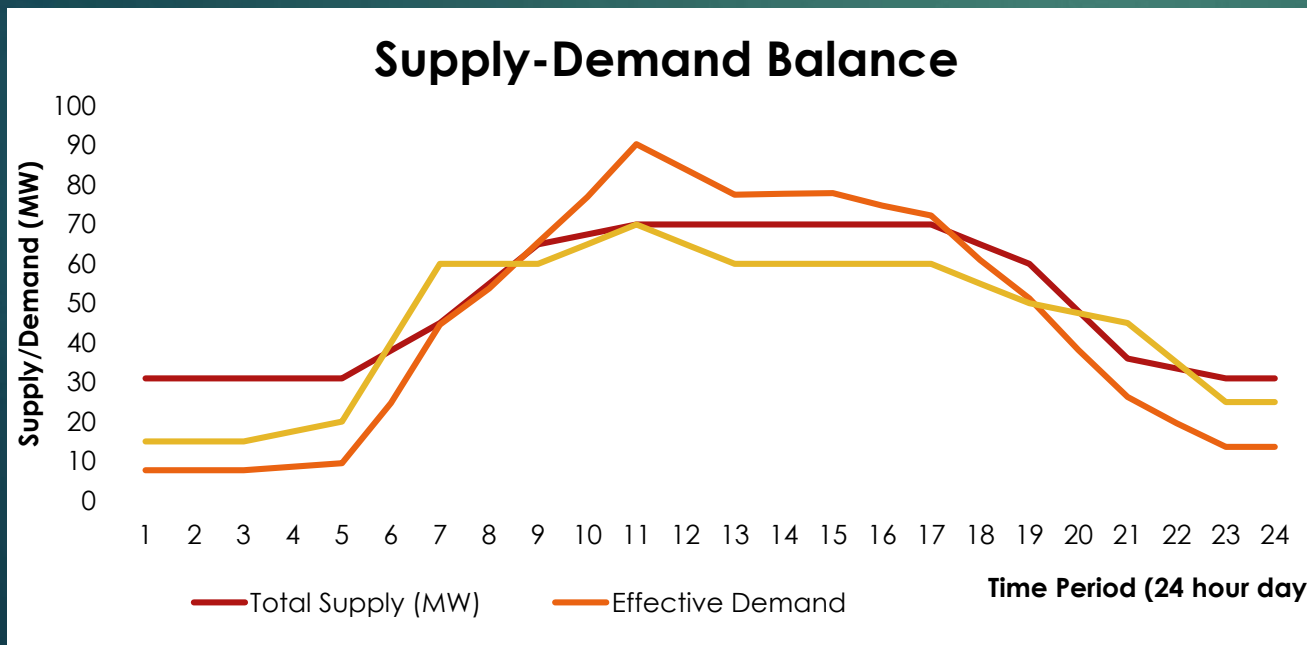
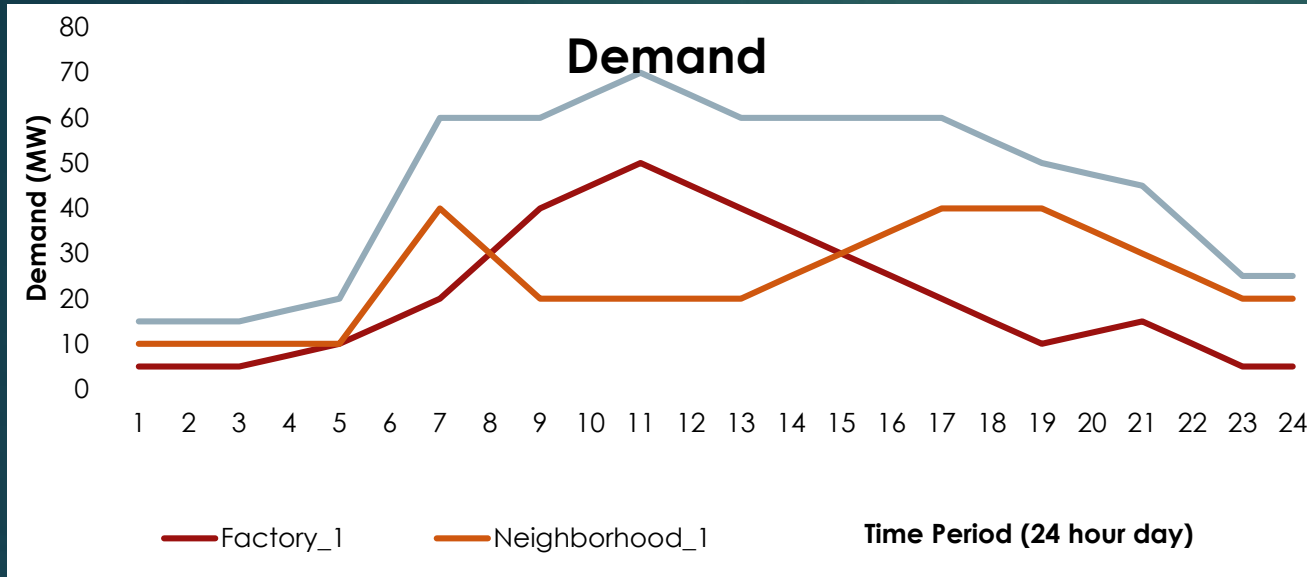


par [Block] Regional_Energy_Supply [Regional_Energy_Supply]





Energy System Analysis



Why MBE Should Look Like Facebook

- It should tell you what's happened overnight
- It should be available 24/7 from multiple portals
- All your friends should be on it
- You can comment on your friend's stuff
- It should protect your private information
- It should make you aware of connections you didn't know existed

Summary

- The goal of Model-Based Engineering is to create a single, unified model (a Graph) extending over all the tools and data repositories the energy industry uses.
- MBE is more about creating and exploring connections than making lists or building structures.

Questions and Comments?

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