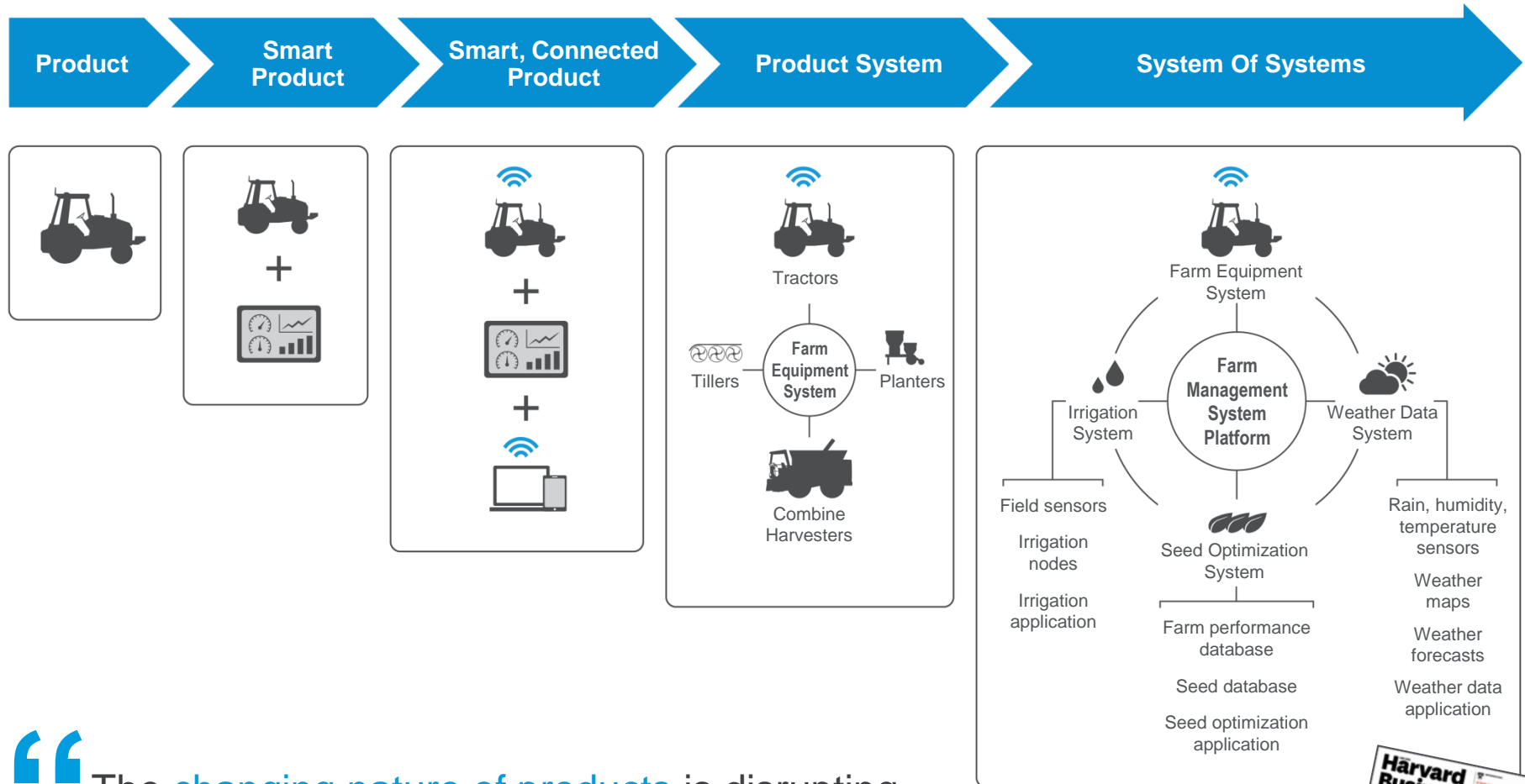


## October 2015

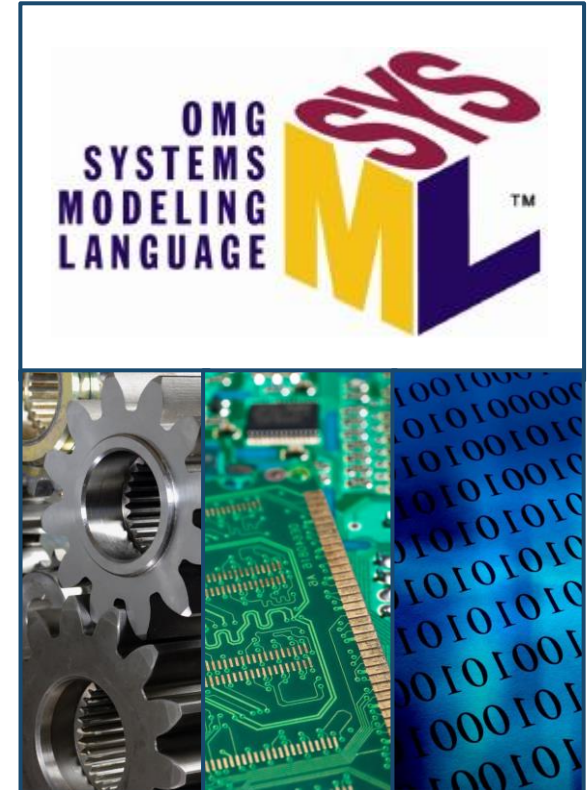


“The **changing nature of products** is disrupting value chains, **forcing companies to rethink and retool** nearly everything they do internally.”



## Design before you build

- **Standard based graphical modelling**
  - Common language
    - Improves understanding
    - Facilitates collaboration
    - Achieves stakeholder buy in
  - Problem abstraction, to see the 'wood from the trees'
- **Systems engineering process automation**
  - Tools enable a more efficient systems engineering process
  - Tangible designs to review, finding problems earlier
  - Traceability from requirements through models to system
  - Enables Rapid Prototyping, Simulation & Trade Studies
- **Reduces the total cost of systems engineering**
  - Reduce learning curve & cost with an industry standard language
  - Capture system design IP to reduce risks & retain value
  - Optimized allocation to mechanical, electrical & software engineering
  - Design & build the right systems, right



## Product line explosion

- Increasing number of product families
- Increasing number of products in families
- Understanding product similarity
- Maximizing reuse
- Understanding product variations
- Deciding between options
- Development cycle time
- Commercial product needs
  - Customize existing capabilities to suit client requirements
  - Redeploy common systems & software to the Market
  - Time from requirements to cash



- Orthogonal Variability Modeling (OVM)
- The concept of 'Variability' Modelling in OVM
  - Variation Points
  - Variants
  - Variability Constraints
- Integrates variability modeling with systems modeling
- References:
  - ISO26550:2013 – Reference Model for System and Software Product Line Engineering and Management
  - Klaus Pohl, Günter Böckle, Frank van der Linden, Software Product Line Engineering – Foundations, Principles, and Techniques, 2005

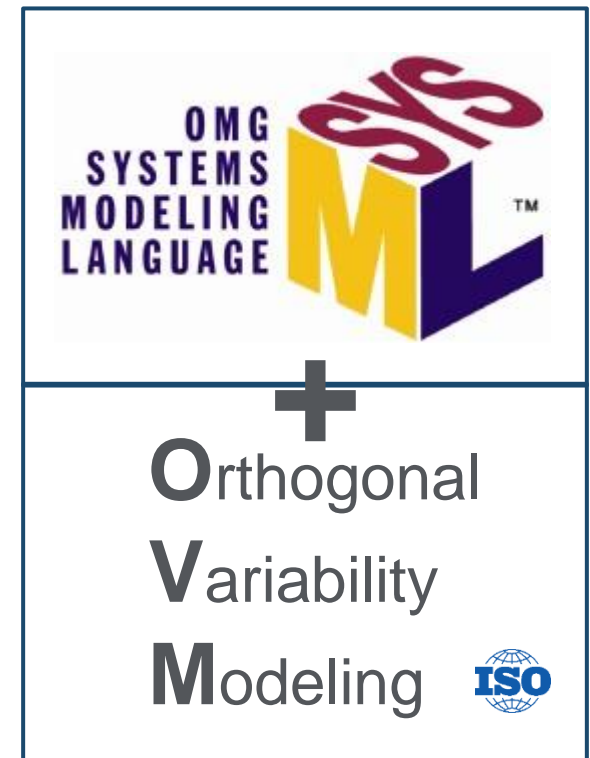
Designing a single system platform rather than as creating a multitude of products

- **MBSE + Modular Design + Variation**

- Common language improves
  - Communication
  - Collaboration
  - Stakeholder buy in
- Architected modular design & reuse
- System product lines designed up front

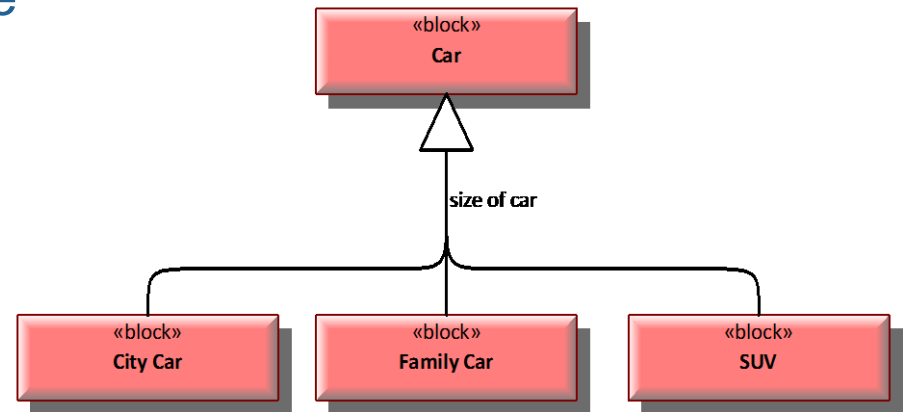
- **Maximum commonality & minimal variation**

- Less duplicated effort with optimized reuse
- Parallel working through 'design by contract'
- More commonality between designs and implementations
- Managed product line complexity

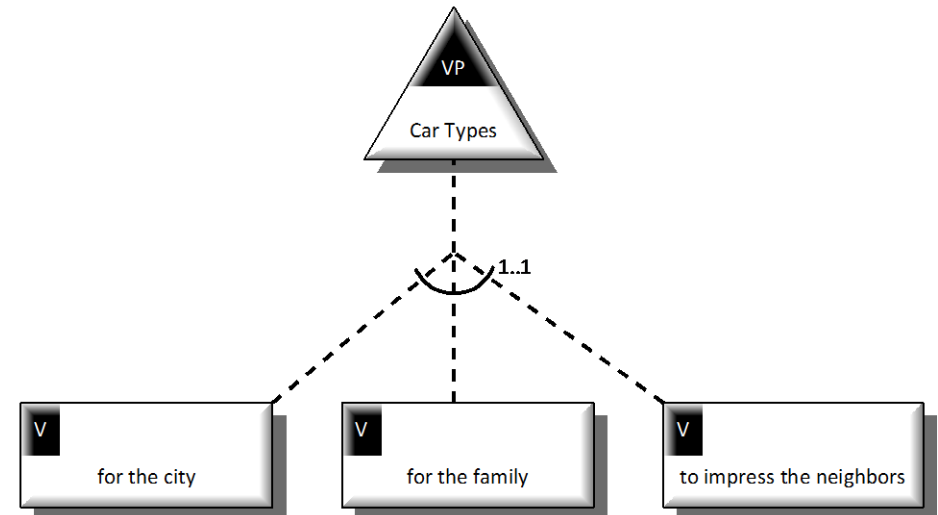


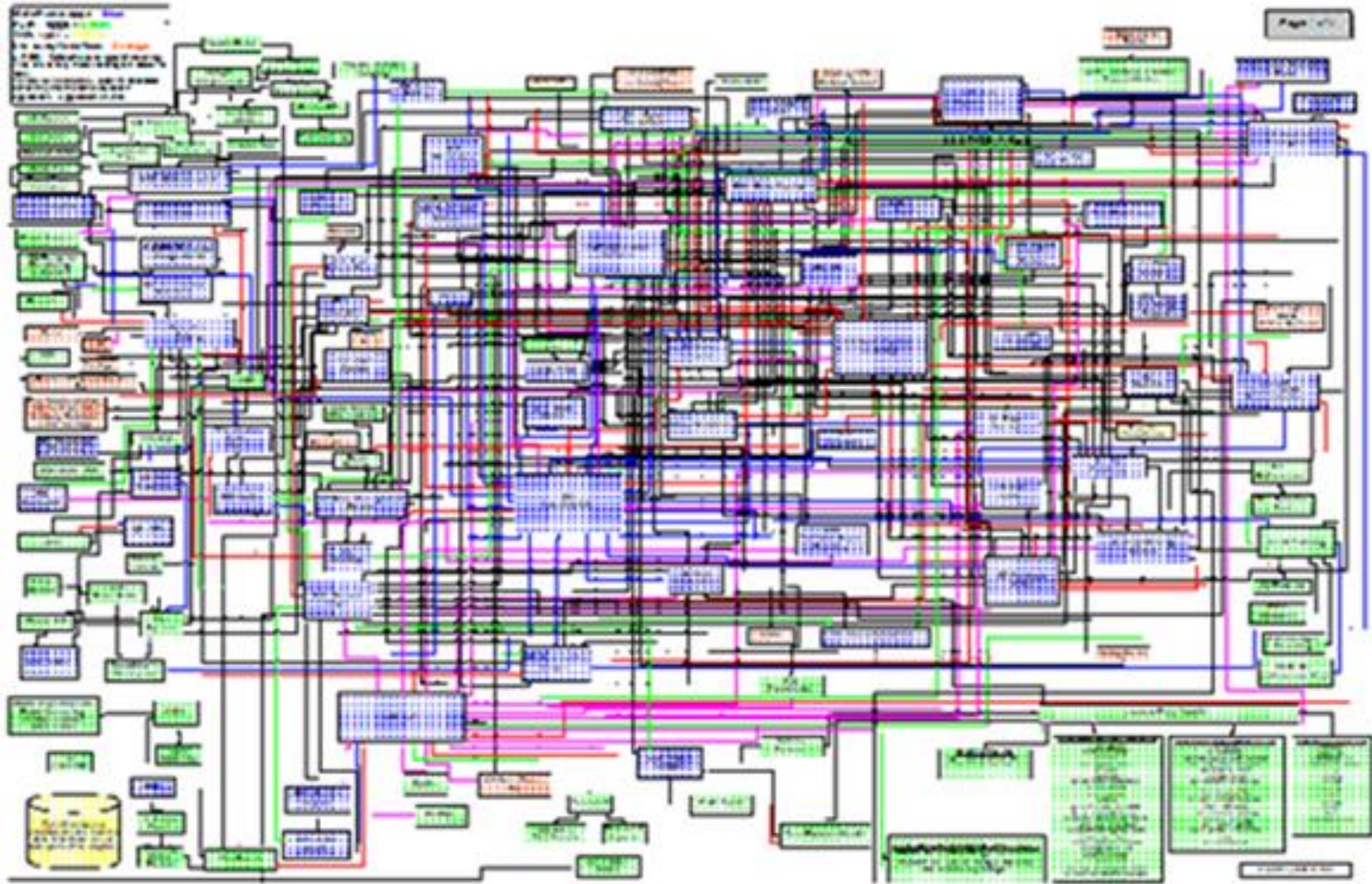


- Model Variability using inheritance



- Model Variability using OVM
  - Orthogonal Variability Modeling







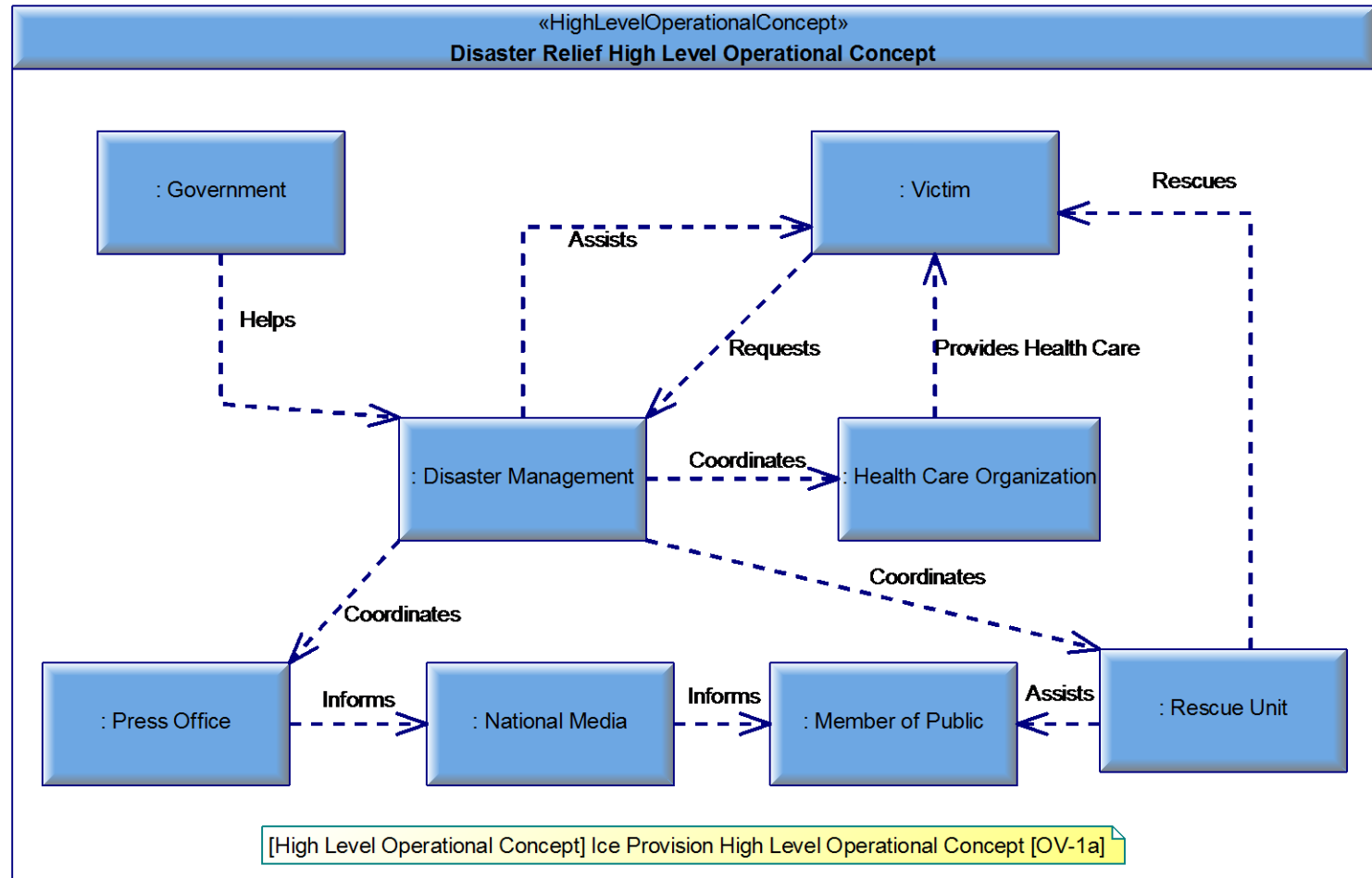
# Model-Based Systems Engineering

# Disaster Relief Challenge....Provide Ice:



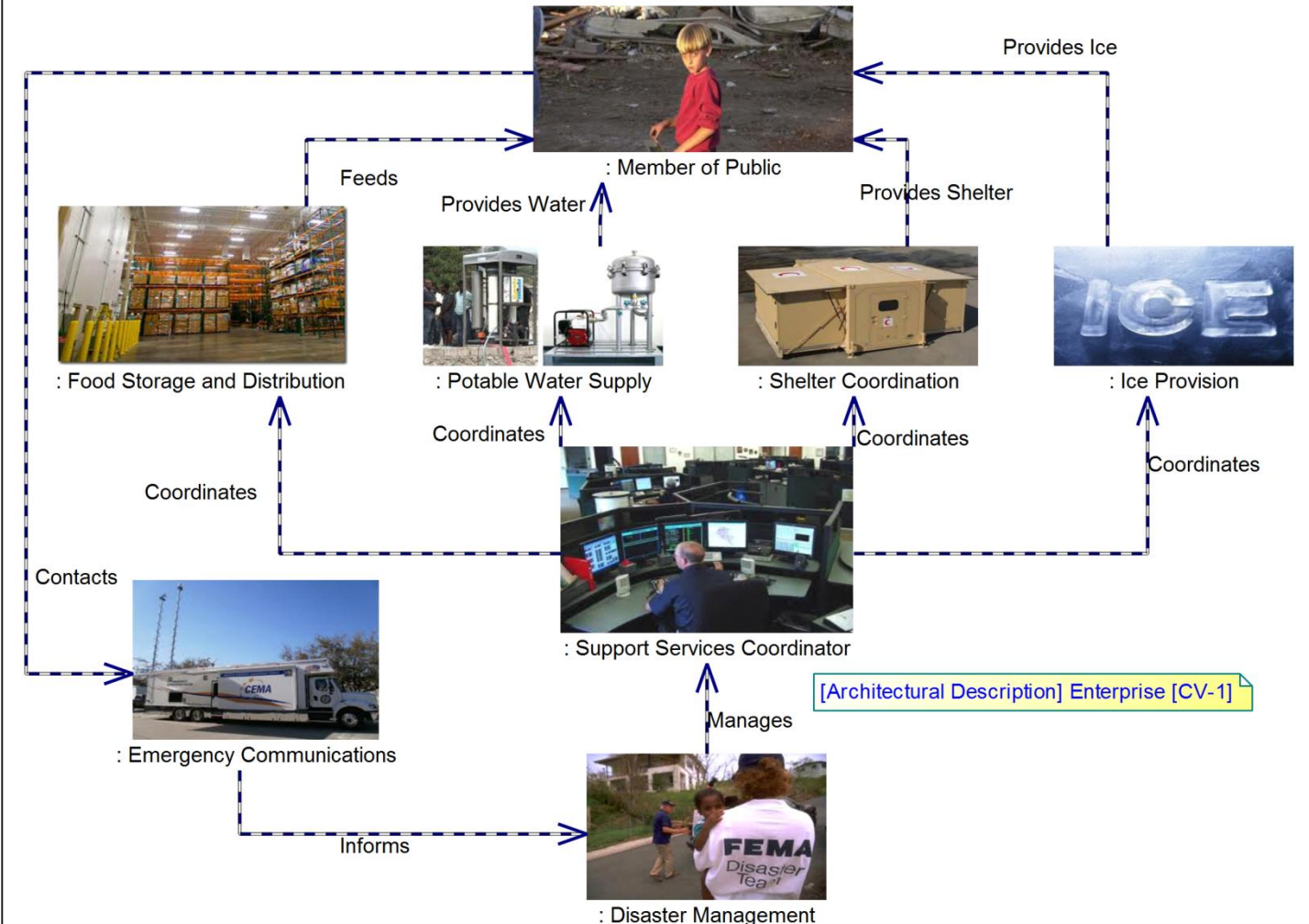
- **Goals and Objectives:** For the challenge, show how today's tools can be used and integrated together to support planning, analysis, decision making, communications, and documentation and reporting while minimizing duplication of effort, or data entry. Refer to the listing of Goals and Objectives posted on the [TVC page](#) for a full listing of all Goals and Objectives to consider including as part of your demonstration.
- **Challenge:** It is summer time in Sin City, a dessert city located in a hot, dry climate zone experiencing temperatures ranging between 70 – 100 degrees Fahrenheit (20-35 C). A recent natural disaster has devastated the area within a 100 mile radius. An estimated 15000 people lost power due to the destruction, and need to find shelter. Most roads are impassible to the public so there is limited vehicle transportation and the electricity is out in most of the disaster area. As part of emergency response requirements, shelters must be set up within 24 hours from when the evacuations begin to help sustain those who need to relocate. As part of the initial emergency response, ice must be provided to sustain perishables such as medicine and foods, and to support first aid needs. Power and potable water are to be provided with the shelter solution.

OV-1a [Disaster Relief High Level Operational Concept] High Level Operational Concept [OV-1a]

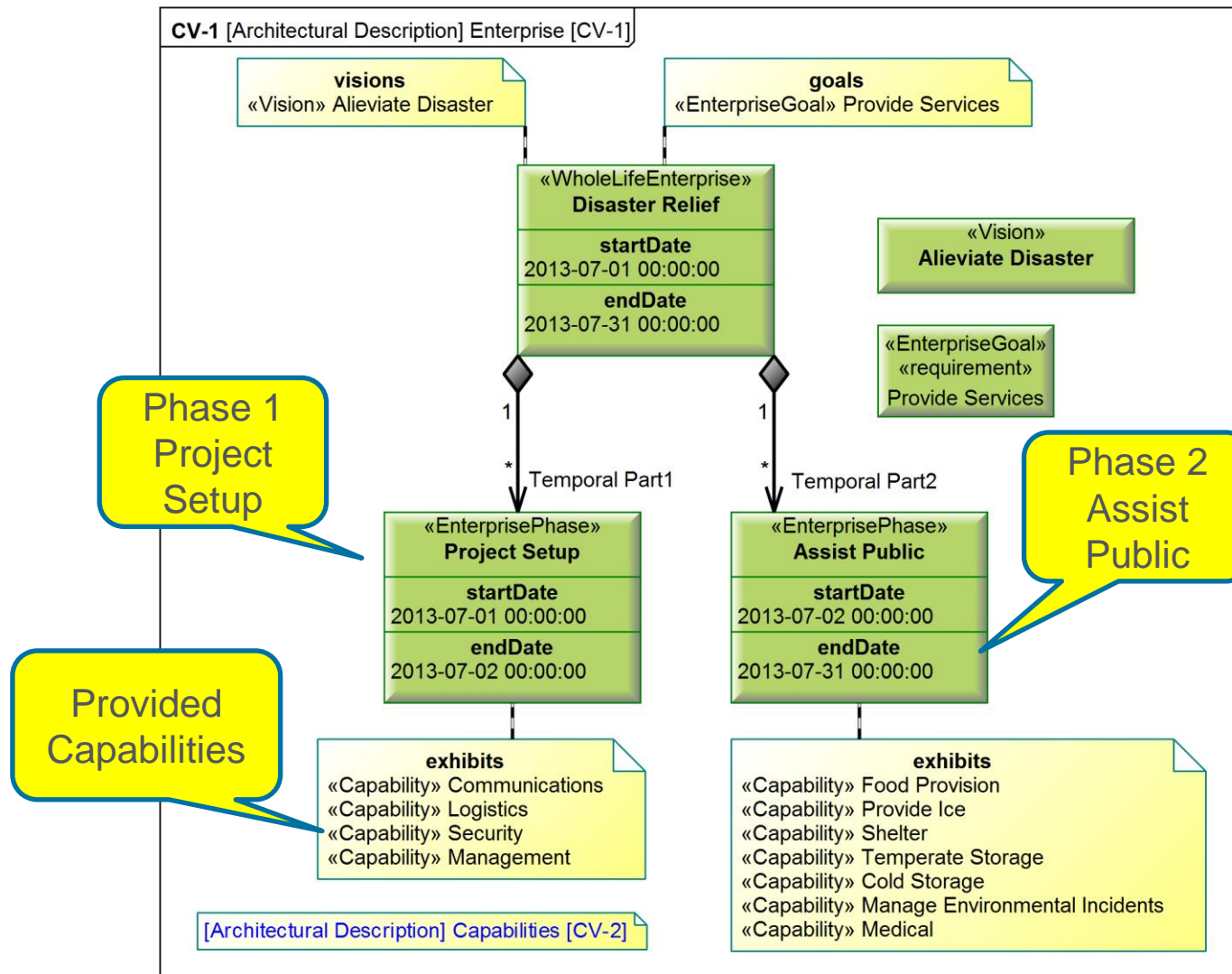


# Operational Concept for Disaster Relief Internals

OV-1a [High Level Operational Concept] Ice Provision High Level Operational Concept [OV-1a]

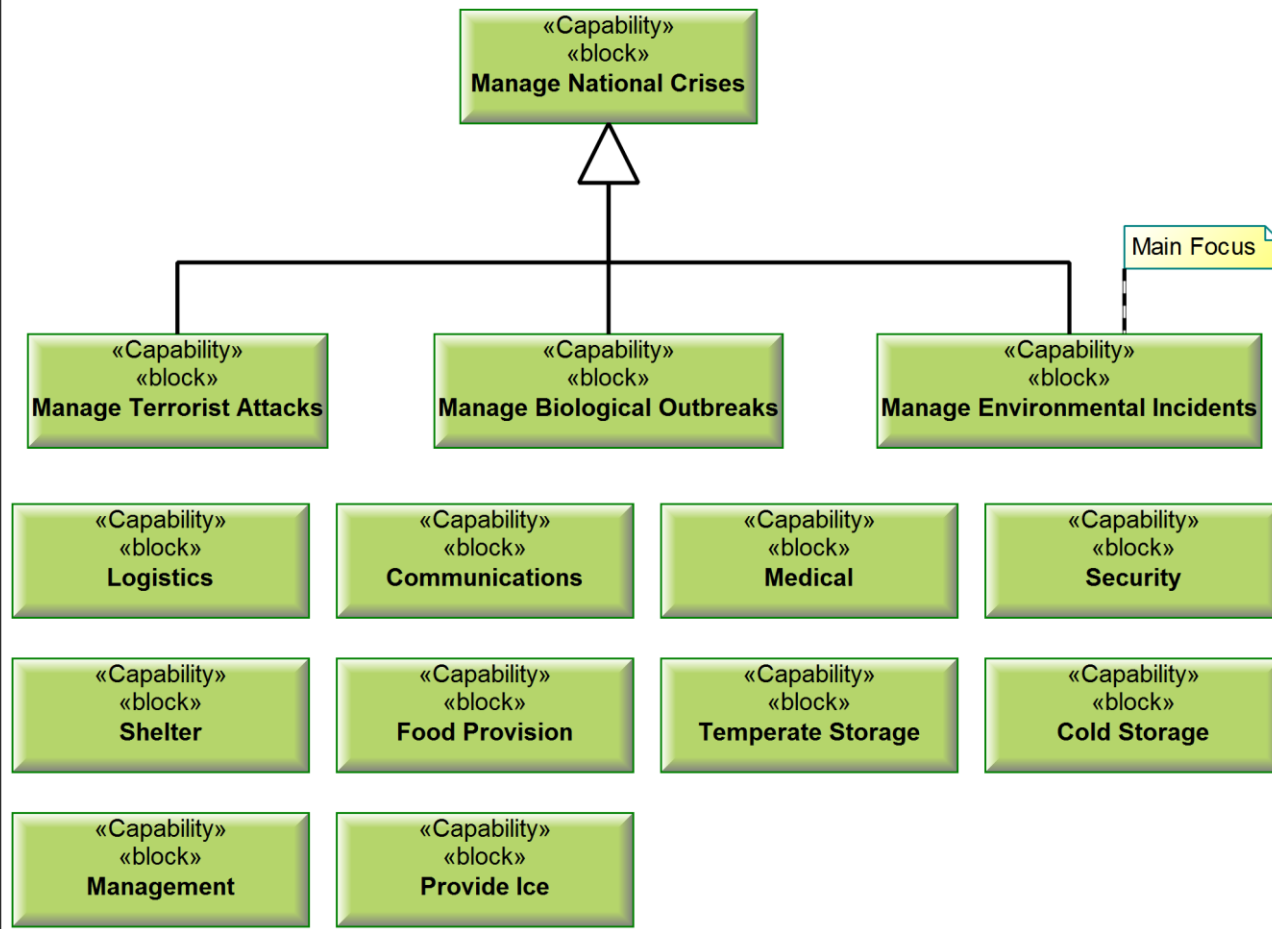


# High Level View of the Enterprise



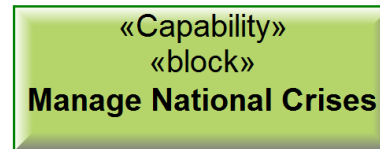


## CV-2 [Architectural Description] Capabilities [CV-2]



# Functional Decomposition of Capabilities

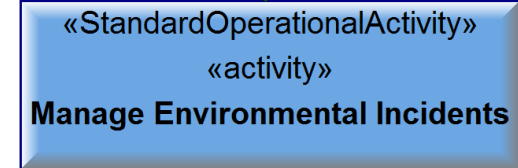
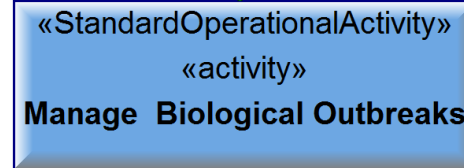
**CV-6 Manage National Crises - [CV-6]**



«ActivityPartOfCapability»

«ActivityPartOfCapability»

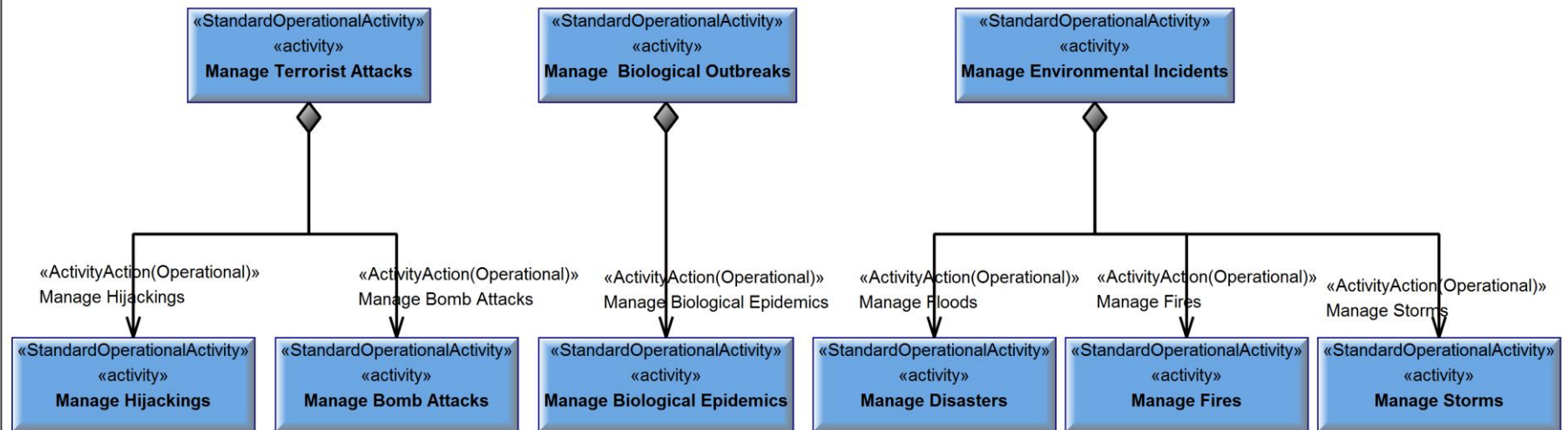
«ActivityPartOfCapability»



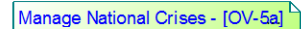
Manage National Crises - [OV-5a]

# Functional Decomposition of Activities

OV-5 Manage National Crises - [OV-5a]

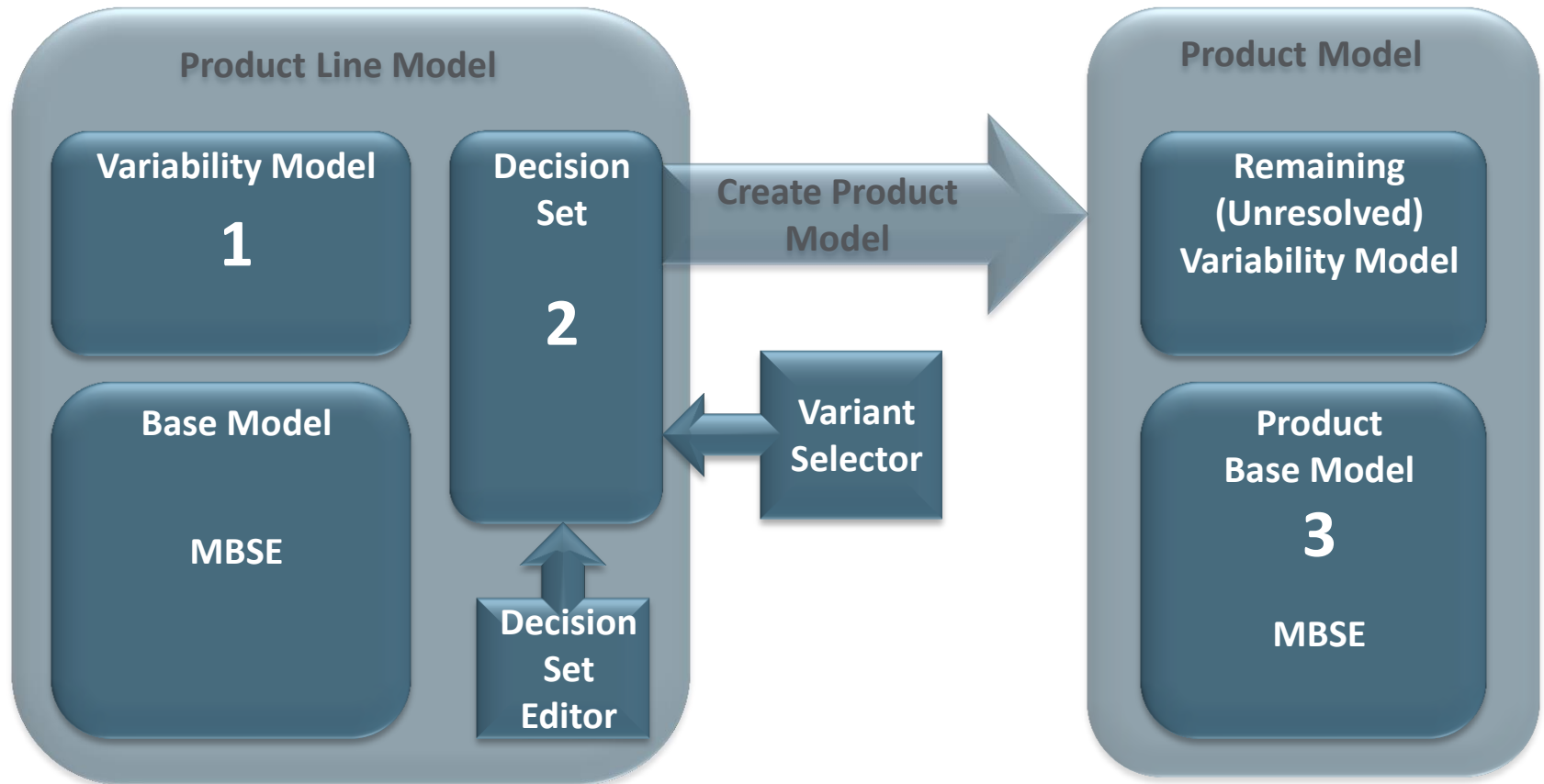


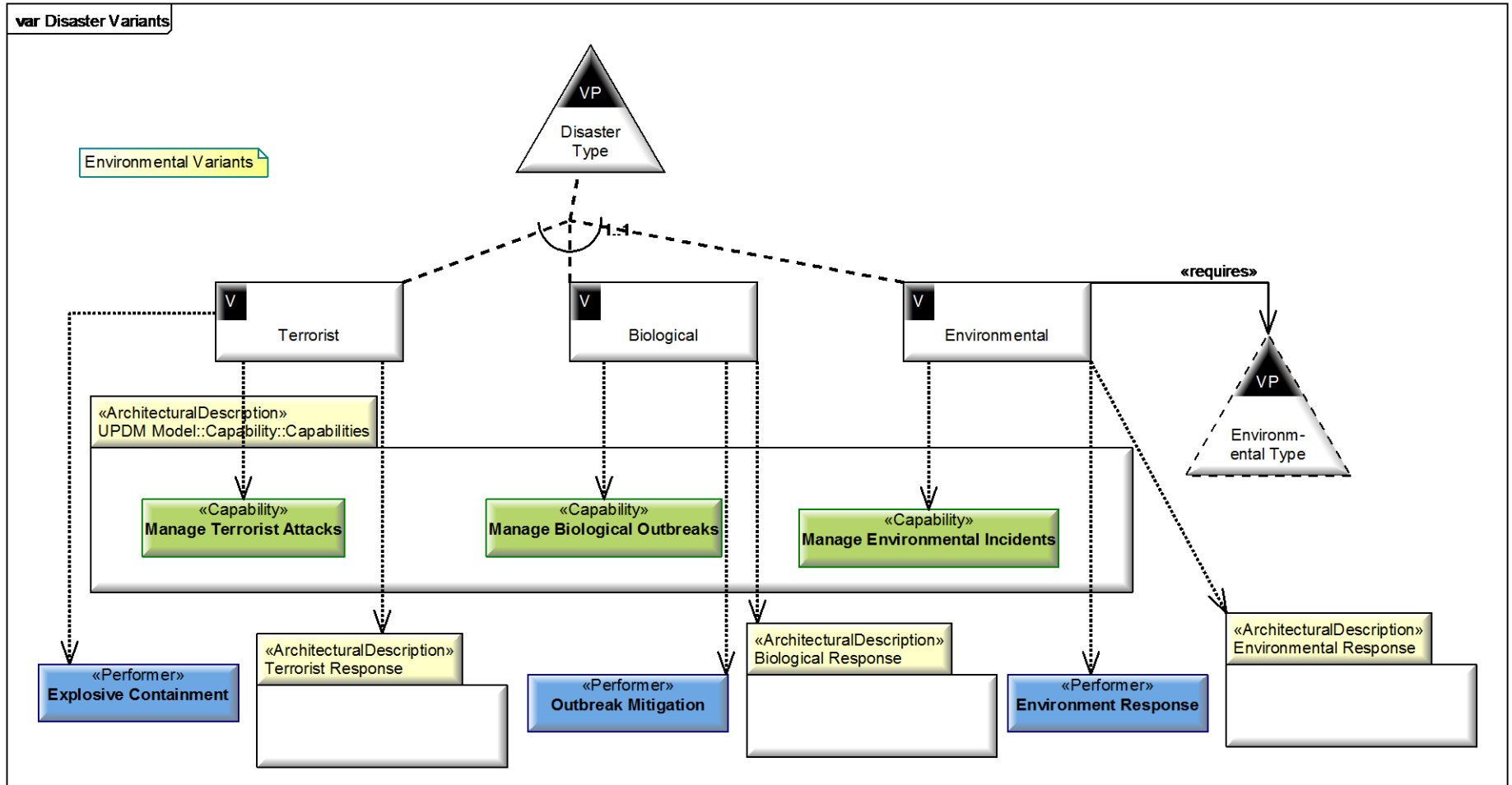
Manage Disasters - [OV-5a]

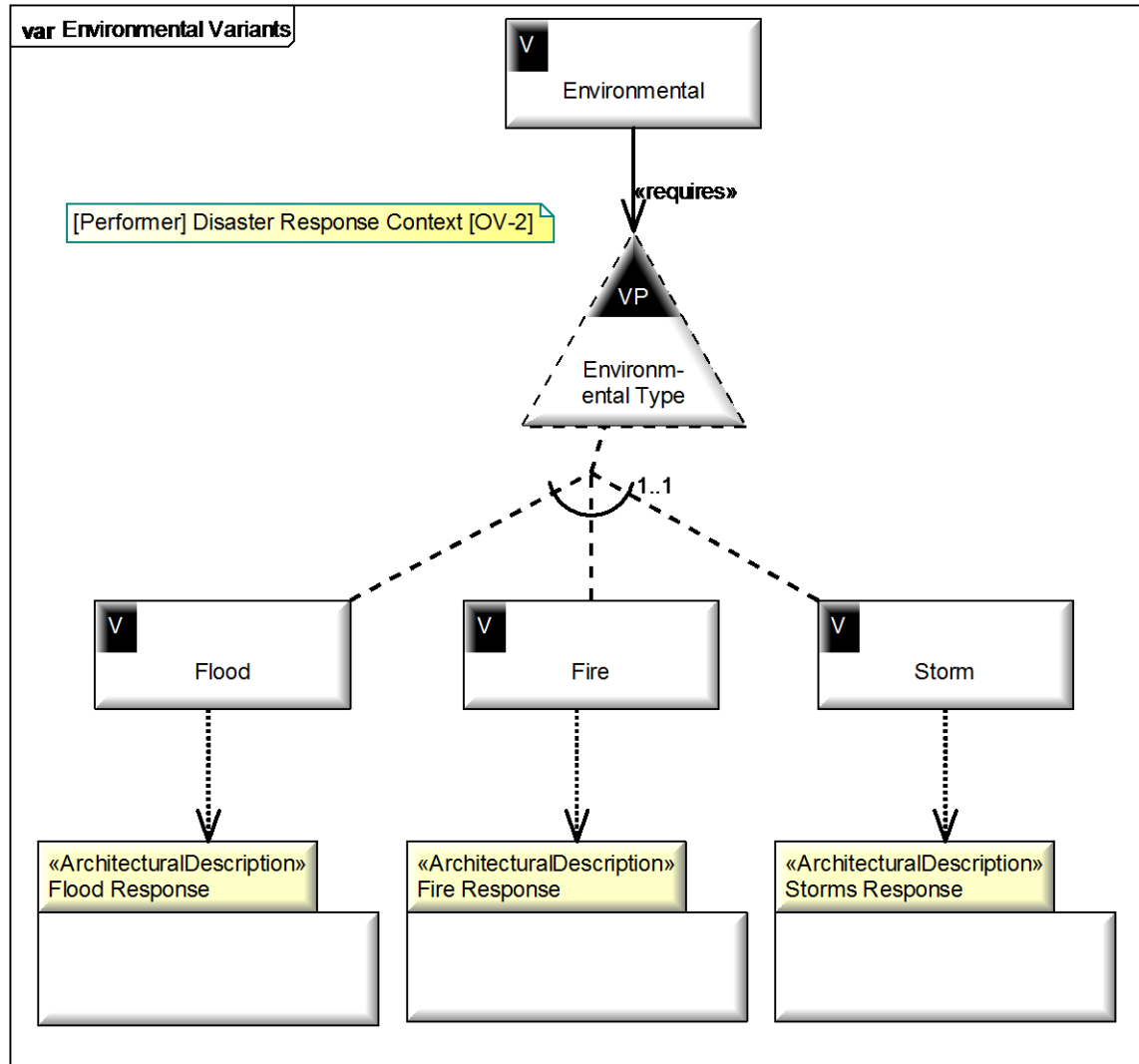


# Model-Based Product Line Engineering









TVC Ice Model 2014, Version 0 - Artisan Studio - [Variability.Disaster]

File Edit View Tools Window Help

BLTS

Packages

- TVC Ice Model 2014
  - +Profiles
  - +SysML Profile
  - +Enterprise Requirements
  - +System Requirements
  - +UPDM Model
  - +SysML Model
  - +Atego Utilities Profile
  - +Variability
    - +Disaster
      - +Biological
      - +Environmental
      - +Fire
      - +Flood
      - +Storm
      - +Terrorist
      - +Disaster Type
      - +Environmental Type
      - +Disaster Variants
      - +Environmental Variants
      - +Comment
    - +[Asset] Distiller System

Variability.Disaster x Environmental Variants x Disaster Variants x

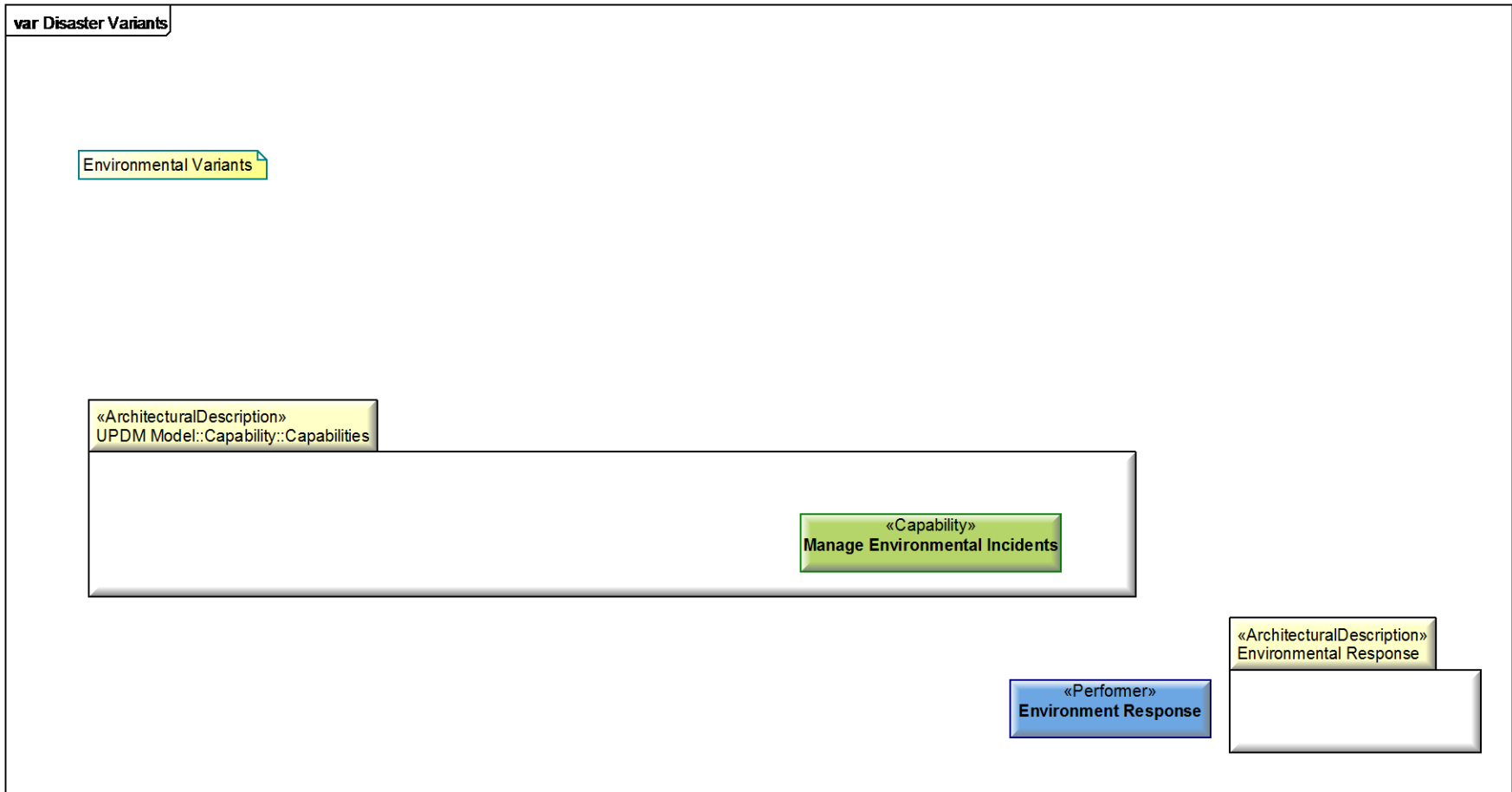
Name	Decision	Status	Included By	Excluded By	Reason
M E <input checked="" type="checkbox"/> Disaster Type		Included	Variability.Environmental		
<input type="checkbox"/> Terrorist	Exclude	Excluded			
<input type="checkbox"/> Biological	Exclude	Excluded			
<input type="checkbox"/> Environmental	Include	Included	Variability.Disaster Type.Alternative Choice1		
E <input checked="" type="checkbox"/> Environmental Type		Included	Variability.Flood, Variability.Environmental		
<input type="checkbox"/> Flood	Include	Included			
<input type="checkbox"/> Fire	?	Excluded		Variability.Environmental Type.Alternative Choice1	
<input type="checkbox"/> Storm	?	Excluded		Variability.Environmental Type.Alternative Choice1	

Variants: 6/6 Variation Points: 2/2 Inconsistent: 0 Undecided Mandatory Variation Points: 0

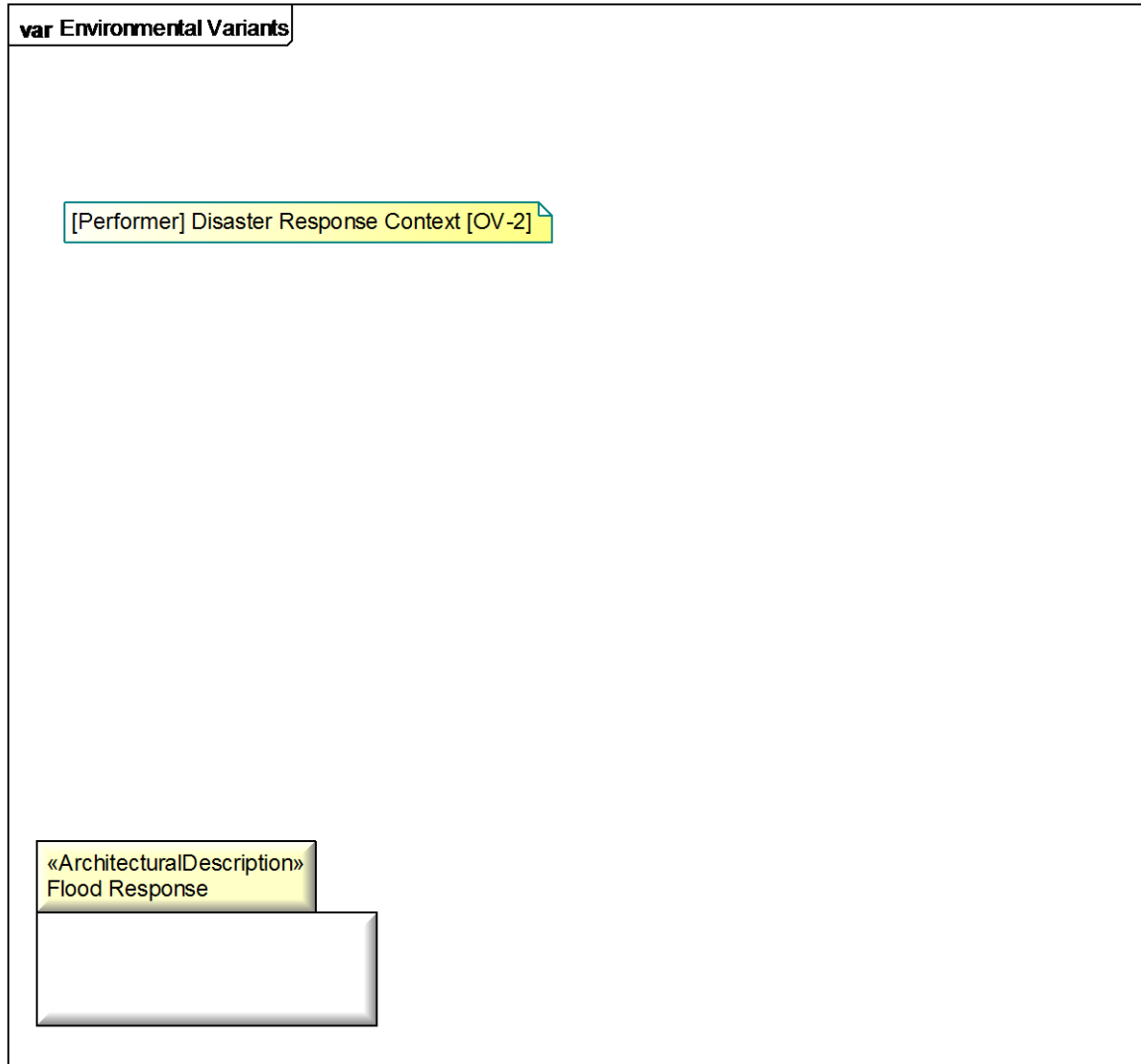
Output

For Help, press F1

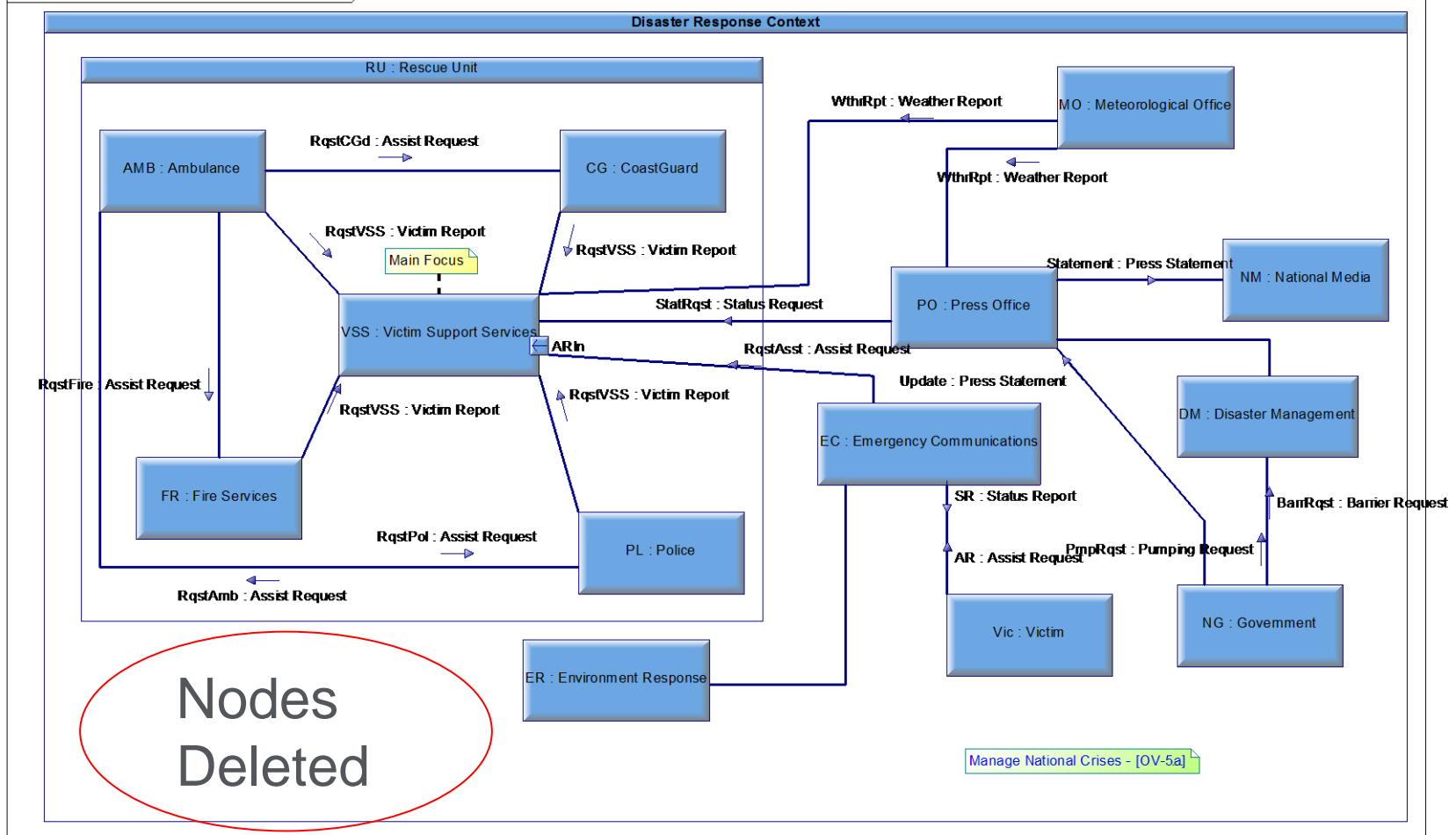
NUM







OV-2 [Performer] Disaster Response Context [OV-2]



OV-5 Manage National Crises - [OV-5a]

Activities  
Deleted

«StandardOperationalActivity»  
«activity»  
Manage Environmental Incidents

«ActivityAction(Operational)»  
Manage Floods

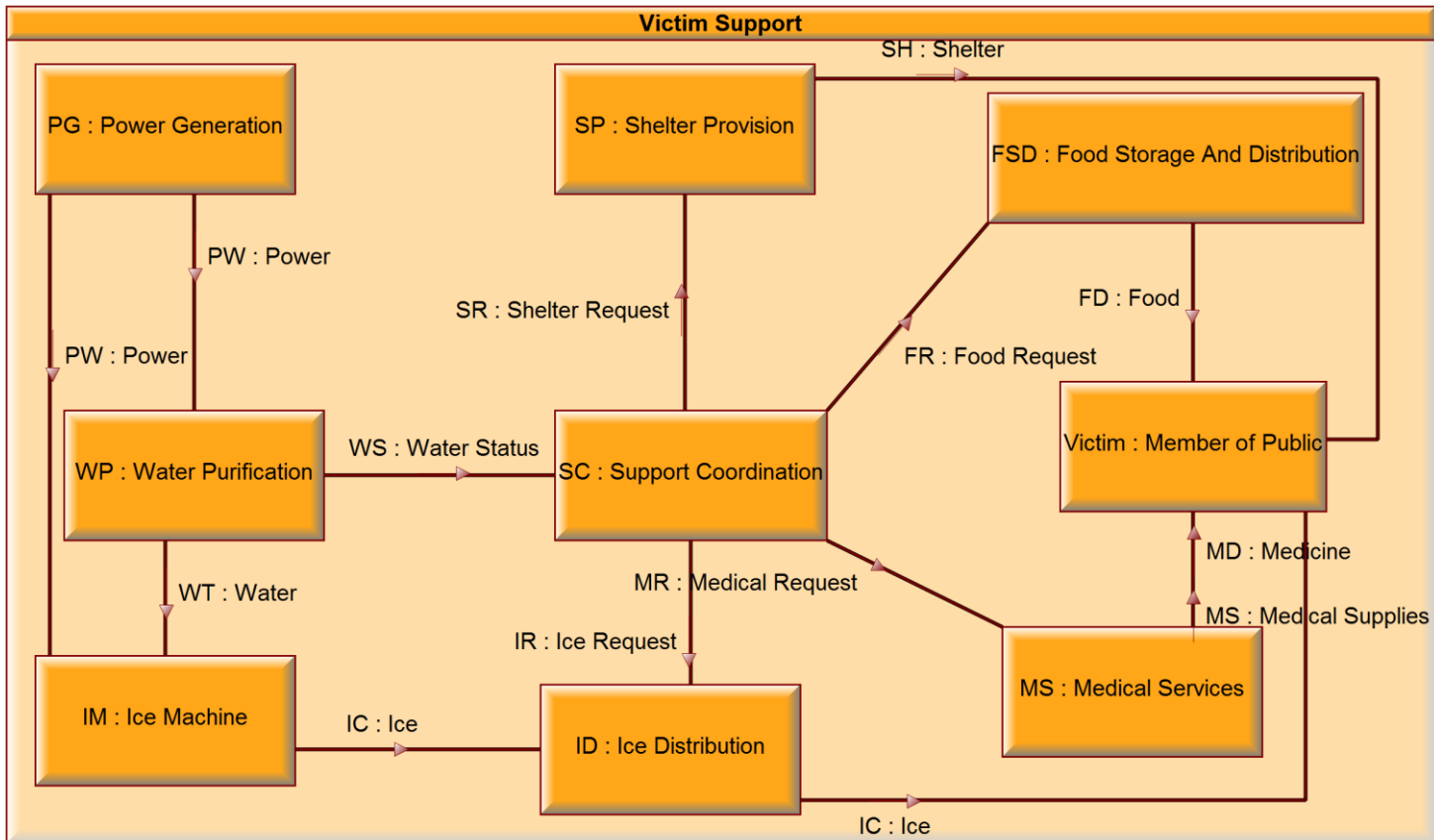
«StandardOperationalActivity»  
«activity»  
Manage Flood

Manage Disasters - [OV-5a]

## Asset Based Modular Design

# System Structure for Victim Support

SV-1 Victim Support - [SV-1]



[Architectural Description] System Structure [SV-3]

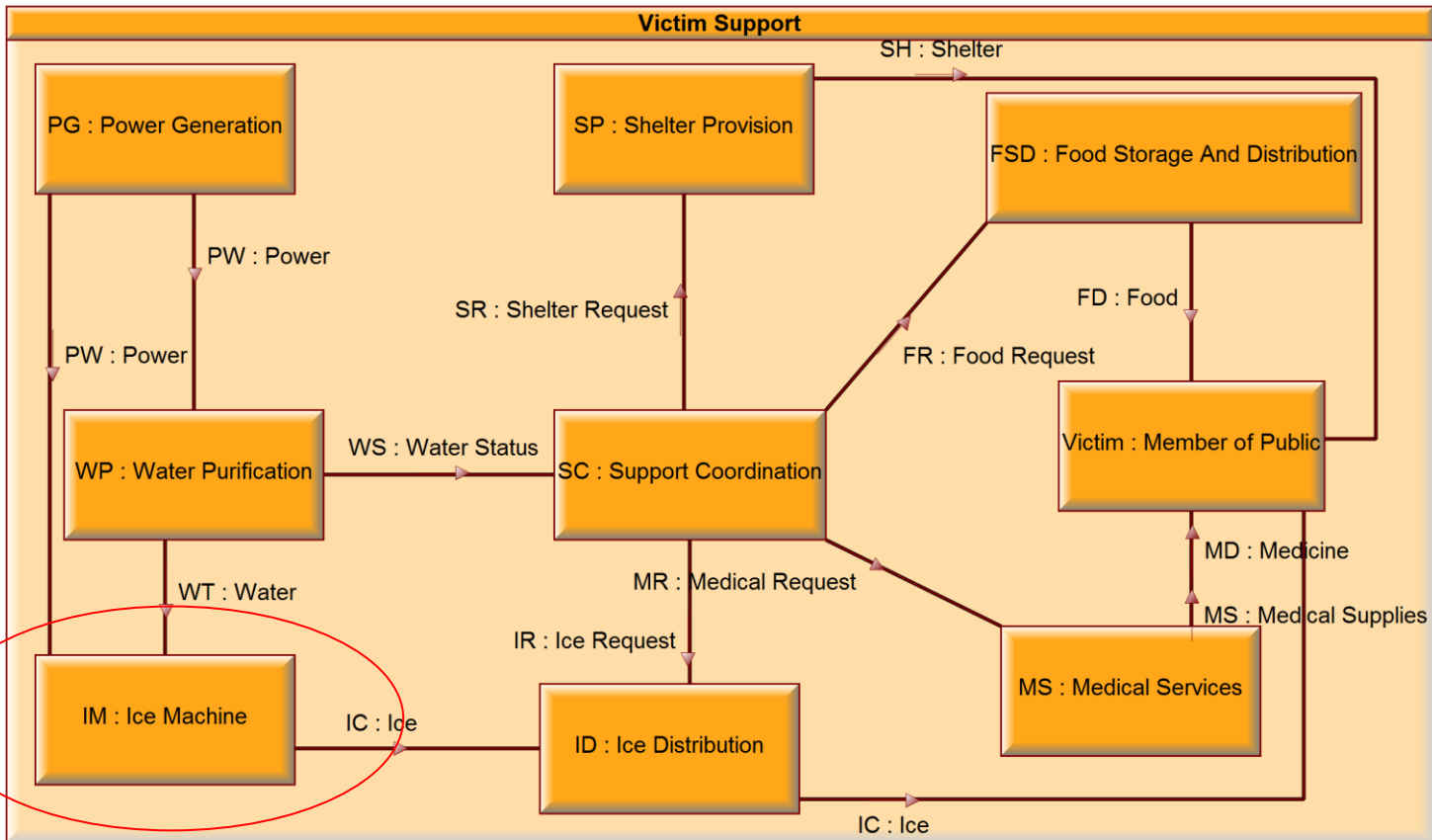
[Architectural Description] System Structure [SV-6]

[Architectural Description] Capabilities [SV-5 Cap - Resource]



# System Structure for Victim Support

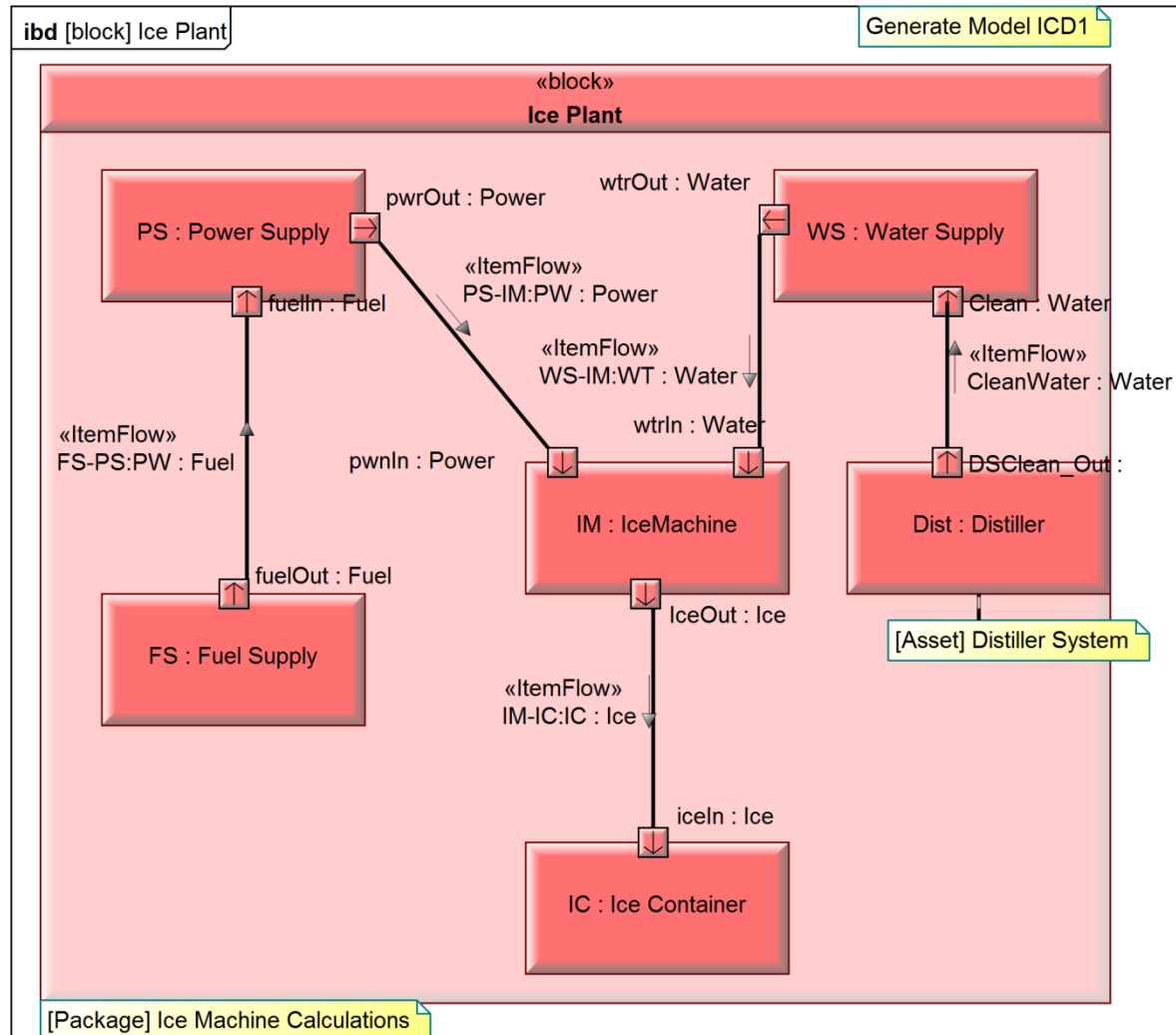
SV-1 Victim Support - [SV-1]

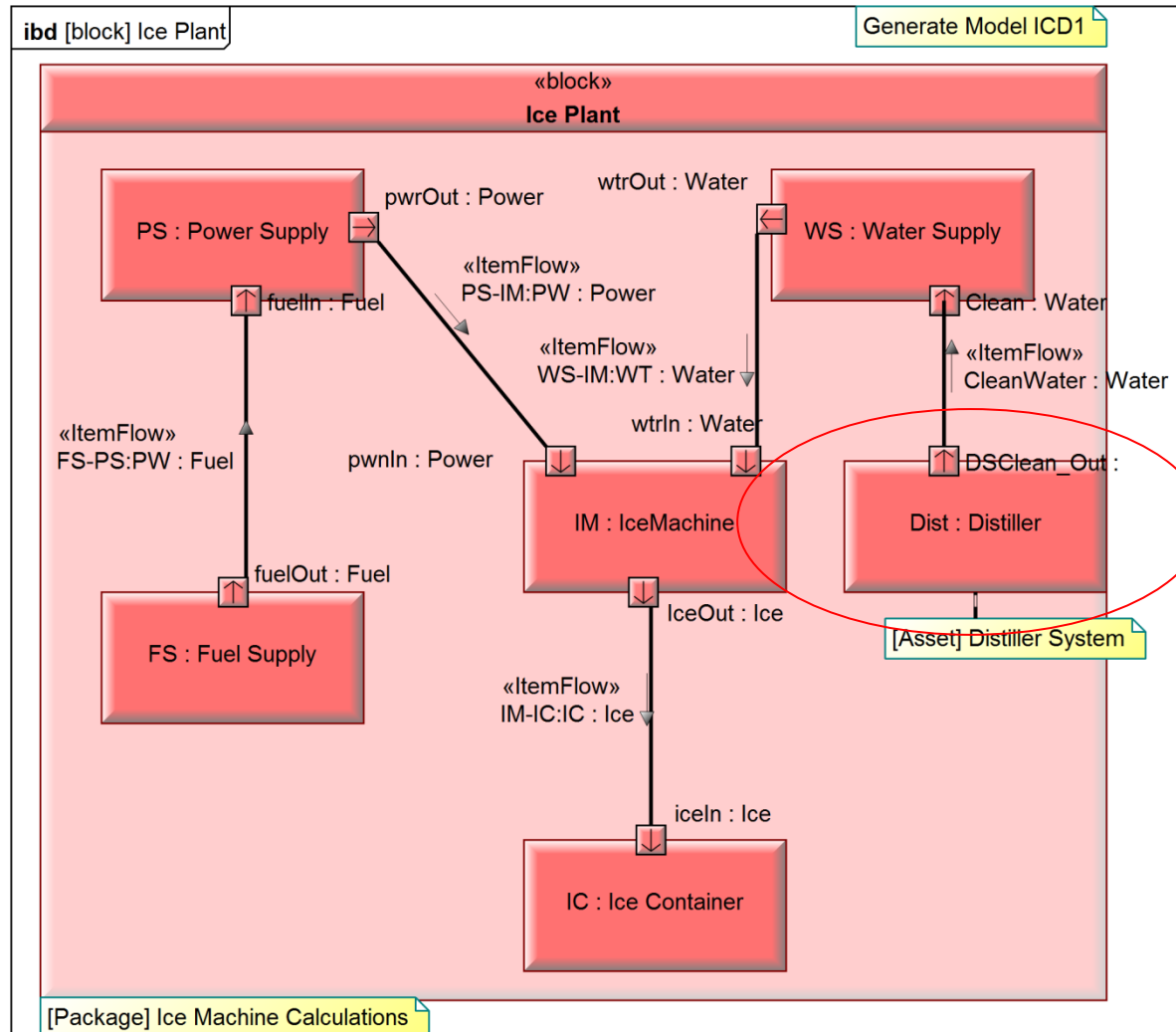


[Architectural Description] System Structure [SV-3]

[Architectural Description] System Structure [SV-6]

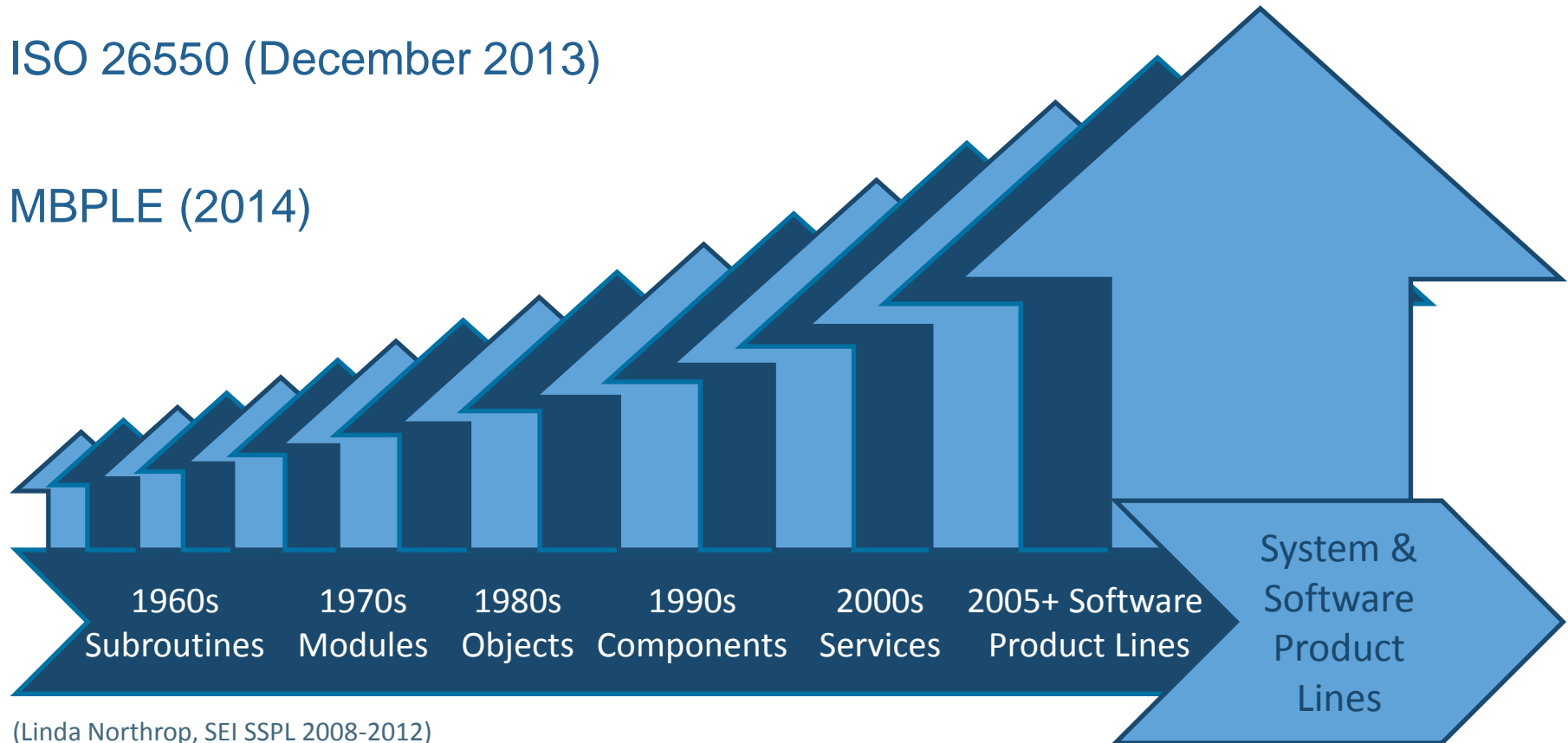
[Architectural Description] Capabilities [SV-5 Cap - Resource]





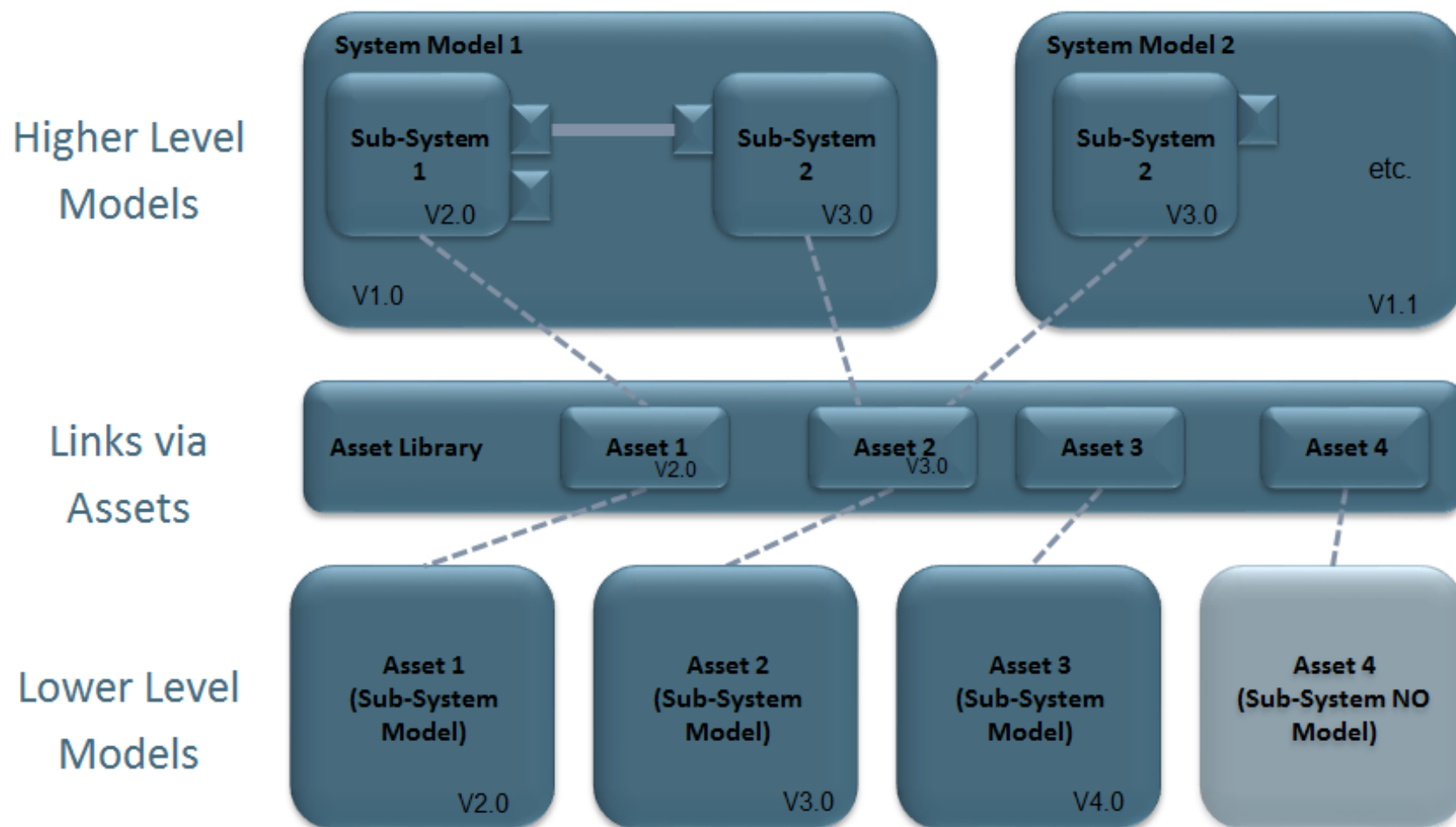
Model-based Systems & Software Engineering (2006) +  
System & Software Product Line Engineering (2001-2008)

- ISO 26550 (December 2013)
- MBPLE (2014)

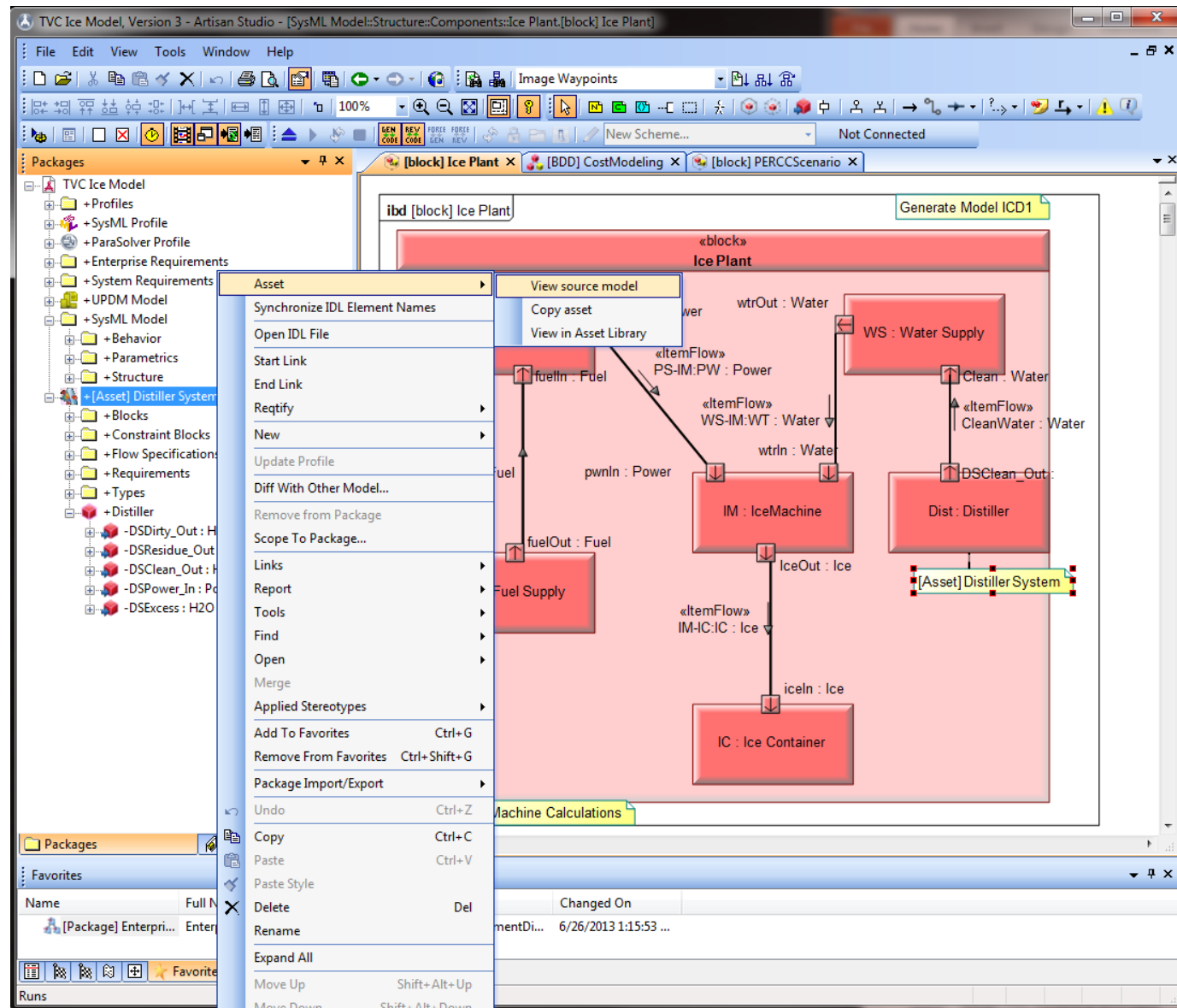


(Linda Northrop, SEI SSPL 2008-2012)

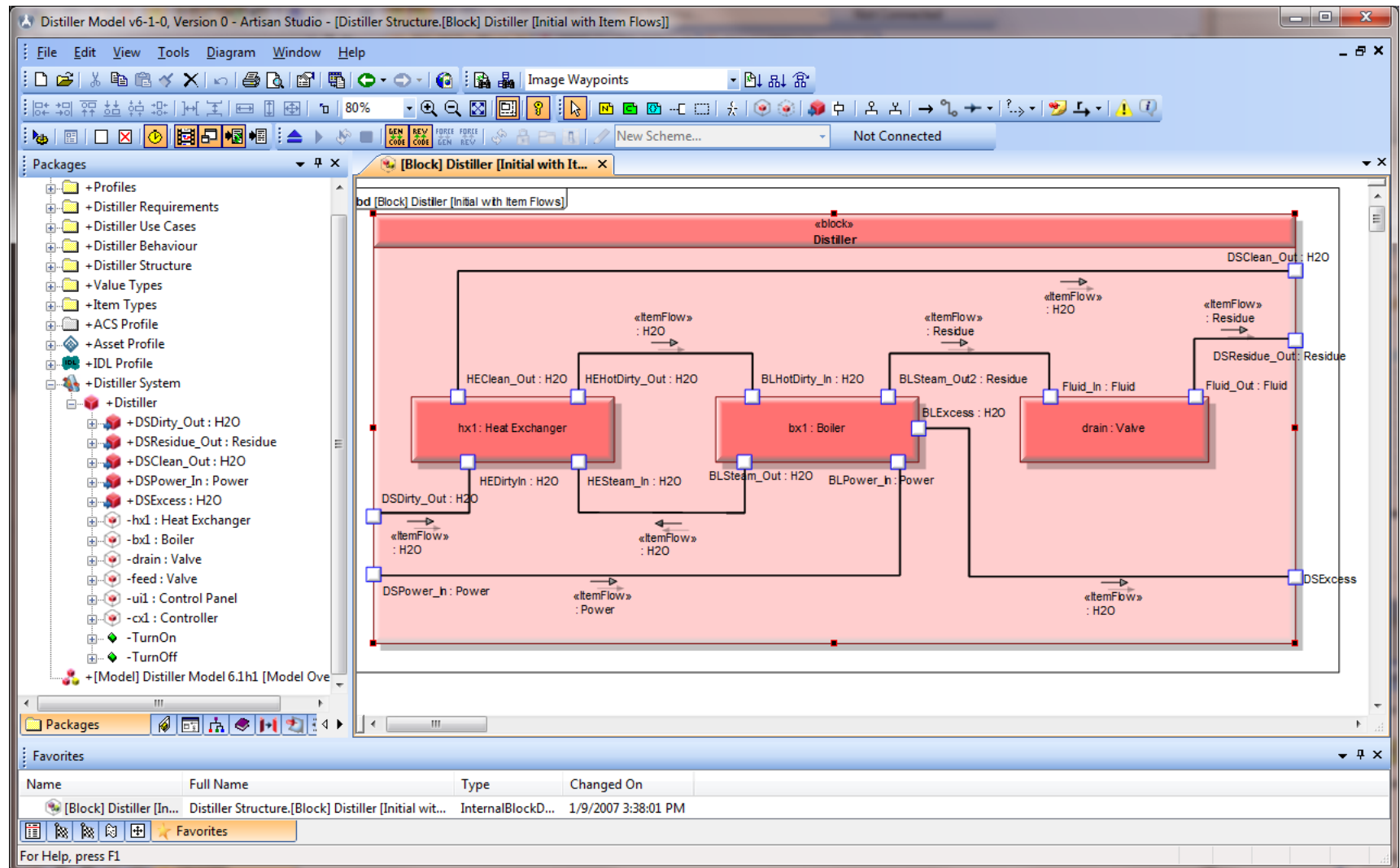
- The OMG Reusable Asset Specification (RAS)
  - Used for defining reusable assets, their interfaces, characteristics and supporting elements
- Three key dimensions describe reusable assets:
  - Granularity describes how many particular problems or solution alternatives a packaged asset addresses.
  - The visibility varies from black-box assets, whose internals cannot be seen and are not modifiable, to white box assets which are visible and modifiable.
  - The articulation describes the degree of completeness of the artifacts in providing the solution.
- Asset also include supporting documentation, requirements addressed, interfaces, etc.
- Provides a standards-based “model of models” approach instead of a “mega-model” approach.



# Asset Library View in other model

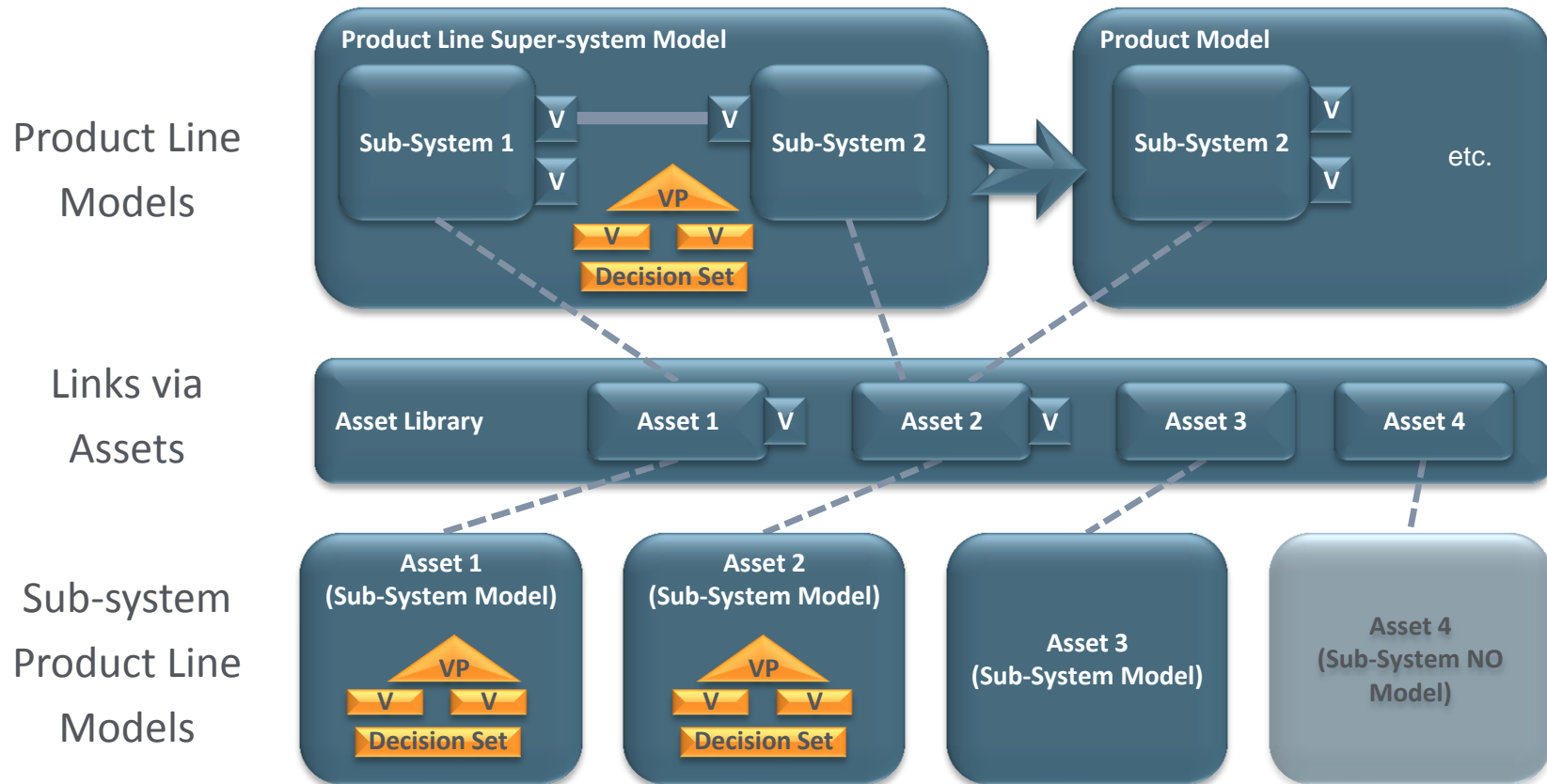


# Distiller model complete system



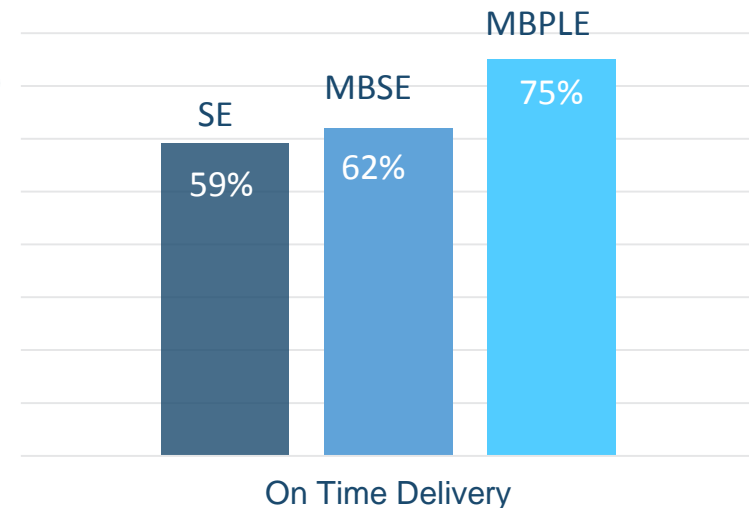
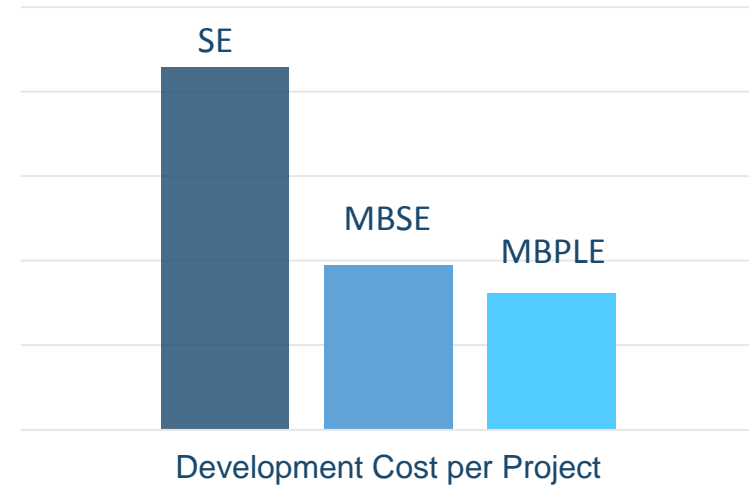


- Integrated MBSE, Modular Design & Variability Modeling = Model-Based Product Line Engineering

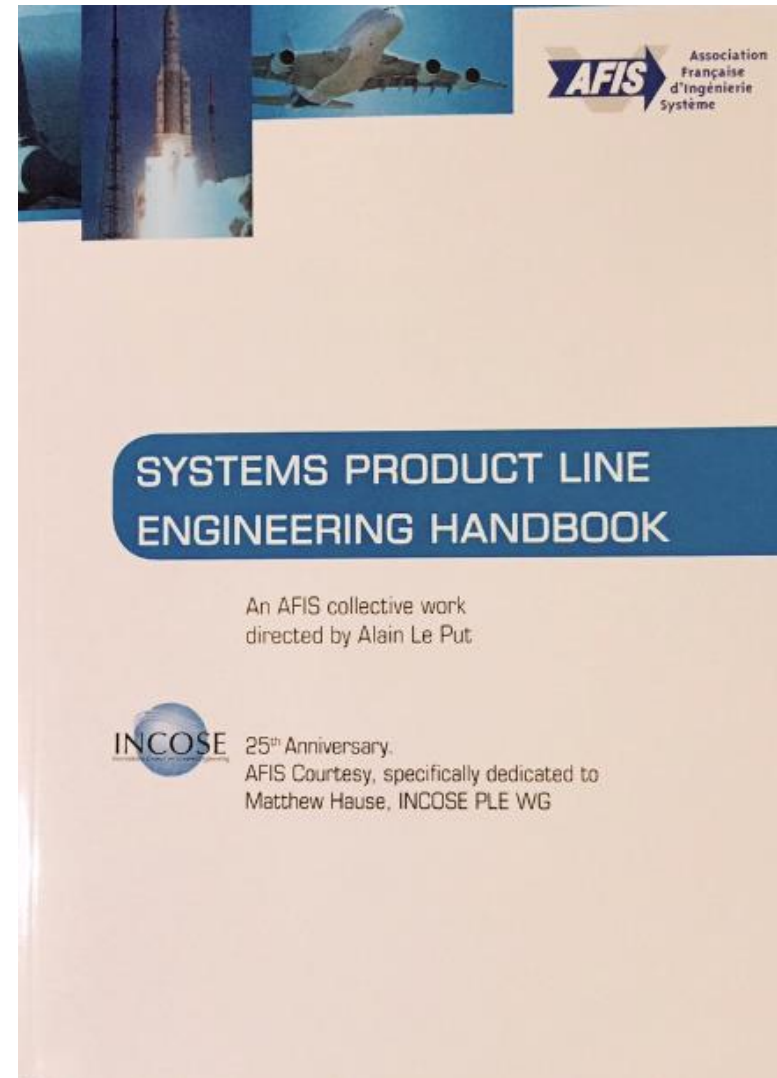


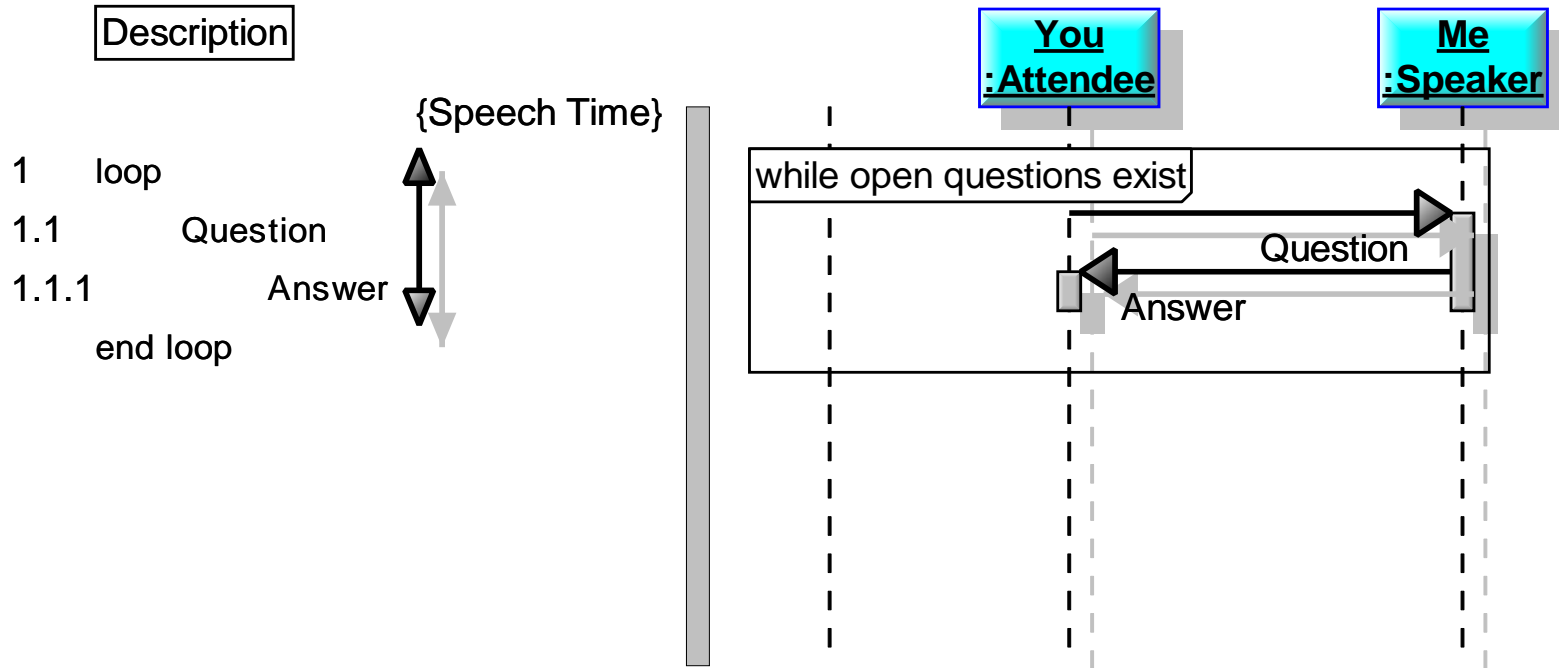
- **SE (Non-Modelled Systems Engineering)**
  - 59% of Projects Delivered on Time
- **MBSE (Model Based Systems Engineering)**
  - 62% of Projects Delivered on Time
  - Compared to SE
  - 55% Reduction in Total Development Cost per Project
- **MB-PLE (Model Based Product Line Engineering)**
  - 75% of Projects Delivered on Time
  - Compared to SE
  - 62% Reduction in Total Development Cost per Project

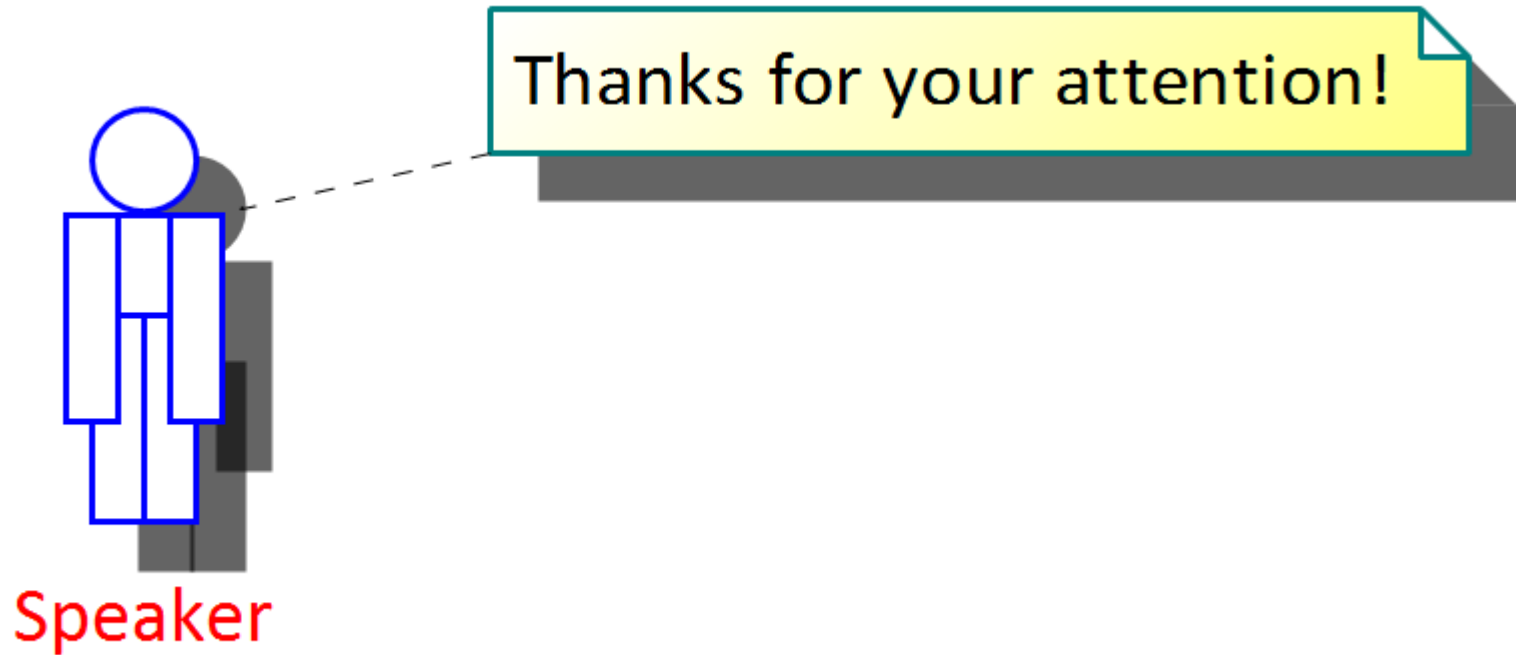
(EMF 2013 Independent Survey Results from 667 Systems engineering respondents)



These books are the foundation of the INCOSE Systems Product Line Engineering Handbook







For more information contact me at:  
[MHause@PTC.com](mailto:MHause@PTC.com)

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ADVANTAGE<sup>®</sup>