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
  • **Syndieia** - 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
MBSE

Consistency
Coherence
Integrity
The Engineering Software Universe

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

Project Domain

- Org’n
  - Project Reqs
    - <satisfy>
    - reference
    - <allocate>
  - Project Flow
    - <satisfy>

WBS

- Product Structure Hardware
  - reference
- Product Reqs
  - <satisfy>
- Product Structure Software
  - <satisfy>

Product Domain

Legend

- SysML Element
- External Tool
Project Requirements into Process Flows

Each system development project will meet these requirements unless specifically exempted by senior (VP or above) management.

A project flow timeline shall be prepared by the product manager at the beginning of the project.

A project flow model shall be prepared and validated by the systems engineering department based on the product manager’s timeline.

A work breakdown structure shall be prepared by the systems engineering department.

The work breakdown structure shall be reviewed and approved by the product manager before going to the Product Plan phase of the project.
Modeling the Project Organization
Linking Project Requirements, Processes, Tasks and Organization
Modeling the Power Plant Structure
Modeling Power Plant Behavior
Modeling Power Plant Interfaces
Linking Power Plant Architecture and Simulation

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[Diagram of 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
Comparing Linked Requirements in SysML and DOORS NG
Comparing Structure in SysML and PLM
How can linked models protect proprietary data?

- Prime’s Model
- Shared Model
- Subcontractor’s Model

Diagram shows flow of shared and proprietary data with selective synchs.
Querying the Graph

• VISUALIZING THE INTERMODEL CONNECTIONS
• VISUALIZING EXTENDED CHAINS
• QUERYING THE GRAPH DATABASE (PROTOTYPE)
Global Visualization

- Windchill
- Simulink
- NX
- GitHub
- JIRA
- SysML (MagicDraw)
- Jama
- MySQL
- DOORS NG

**Totals (Inter-model analytics)**
- # connections (c) = 140
- # connected artifacts (a) = 230
- connection density (c / a) = 0.61

**Repositories (Artifacts per repository)**
- MySQL repositories
  - MySQL_1 (7 artifacts)
- File system repositories
  - Simulink (45 artifacts)
  - Simulink_Shared (0 artifacts)
  - Excel (2 artifacts)
  - SampleDocs (0 artifacts)
  - Creo_Models (9 artifacts)
  - NX_Models (1 artifacts)
- Teamcenter repositories
  - TC_2 (0 artifacts)
  - TC_1 (0 artifacts)
Directed Visualization

- SysML (MagicDraw)
- JIRA
- Jama
- Repository Types:
  - MySQL repository
  - File system repository
  - Teamcenter repository
  - Windchill repository
  - GitHub repository
  - DOORS-NG repository
  - Jama repository
  - JIRA repository
  - SysML model elements
Query: Show me all the SysML requirements
Query: Show me all the SysML requirements connected to Jama requirements
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
Query: Is GitHub file “Plant_Safety_Software” connected to DOORS requirement “2433 - Control and Safety Software”? 

[Diagram showing the connection between the GitHub file and the DOORS requirement]
Building a Bigger Graph

• USING YOUR MODEL IN A LARGER MODEL
• PERFORMING PARAMETRIC ANALYSES
Smart Grid Model
Energy System Analysis
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.