INCOSE IW 2015 MBSE Workshop

• Session Title:
  – Open Services for Lifecycle Collaboration (OSLC)

• Talk Title:
  – Raytheon’s Experience with OSLC

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Motivation

• Adopting Model Based Engineering can be challenging for an organization
• Requires INVESTMENT with unproven PAYBACK
• Demands an approach to “get over the adoption mountain” quickly and effectively

- New processes to define and learn
- New tools to acquire, configure, deploy, and learn
- Legacy artifacts in hand that beg to be leveraged “the old way”
- MBE needs to be proven

- Robust models that drive the system engineering process
- Traceability and linking to support change impact analyses, system evolution, etc.
- Metrics and assessments
Challenges – Integrating Islands of Models

- Different Integration Standards (if any)
- Correlating Information Assets (What goes with What)
- Naming Conventions and Units of Measure
- Accessibility
Raytheon: Who We Are

- Raytheon Business Focus:
  - Defense
  - Aerospace
- More than 72,000 employees worldwide
- More than 40,000 engineers
- 2012 revenues of $26.5B
Getting over the MBE Adoption Mountain

• Address two aspects of this challenge:

1. Leveraging automation and data import to accelerate adoption

2. Leveraging OSLC linking to provide robust multi-disciplinary linking to achieve measurable benefits of MBE quickly
Case Example

- We wanted to apply MBE on a legacy program for which we had over a hundred B5 specifications, each hundreds of pages long, with thousands of interfaces identified.
- Migrating all that information from documents to a Rhapsody model by hand would be costly, time consuming, and error prone.
- It would delay “getting over the MBE Adoption mountain”
- Our Goal: Extract as much data from these specs as possible and use it to automation generation of a model
Focus first on the Low-Hanging Fruit

• Our B5 specifications included interface tables, both for internal (component-level) and external (element-level) interfaces
• From one of these simple tables it was possible to extract:
  – Sender and Receiver element and component
  – Message identifiers
  – Message names
  – Message descriptions
  – Several key interface parameters (e.g., rates, data classification)
• We realized that we could also generate:
  – Port names
  – Event reception names
  – Cross references back to the legacy specifications (could be OSLC references to DOORS)
• And that we could later add:
  – Data types (extracted from software artifacts)
What did we develop?

- Process and supporting automation to support transition from legacy Document-Based Systems Engineering to SysML Model-Based Engineering
- Proof of Concept used on a large legacy program:
  - Over 100 legacy B5 Specifications and Interface Description Documents processed to extract interface and structure data
  - Process generated thousands of consistent SysML artifacts in the Rational Rhapsody tool
Generated SysML

- Interfaces and Operations on Interfaces
  - Inter-element and component-to-component
- Could have created blocks (but didn’t)
- Events associated with interfaces
- Ports on Elements and Components (with Required and Provided Interfaces)
- Receptions on Elements and Components
- Connections between elements and components
- Delegation ports and connections from elements to components
- Relationships among all the above
Further Simplify using Rhapsody Plug-ins

• Make the automation ever easier
• Rhapsody Plug-ins are automation accessed through Rhapsody menus
  – Developed using Rhapsody API
  – Rhapsody provided plug-ins (e.g., SE Toolkit)
  – User developed plug-ins
• Creating a product plug-in includes:
  – Writing the Java application
  – Creating a .hep file containing requirements for loading the plug-in
  – Attaching the .hep file to a profile
Getting over the MBE Adoption Mountain

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MBE Demands Multi-Disciplinary Linking

- **MBE ~ Model Based Enterprise**
- MBE is not one model but rather a collection of multi-disciplinary models
- Many relationships are missing in today’s MBE approaches
- Establishing and linking relationships is the key to ensure design consistency
- Changes made from one perspective need to be reflected in others
- Complete / Interconnect Models = Complete / Consistent System Design
Model Based Engineering
Just Some of the Challenges

**MBE Definition**

- Model-Based Engineering (MBE): An approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle.
- Model: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. (DoD 5000.59-M 1998)
- Preferred MBE Practices:
  - Models are discipline-specific.
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  - The result is a disciplined model-driven approach to system development.
  - Models are discipline-specific.
- Core to MBE is the integration of descriptive domain models and computational models.

**Challenge**

- **Lifecycle Integration**
- **Stove-Piped Models**
- **Interdisciplinary Teams**

**Potential MBE Costs and Risks**

- Initiating an MBE approach will require investment in tools, training, and infrastructure:
  - MBE must be institutionalized to be cost effective.
  - The initial investment may be prohibitive if only used on one project.
- MBE approaches and tools will not replace strong, rigorous, and disciplined enterprise processes:
  - They must be integrated with the processes.
- Training is necessary, but not sufficient.
- Must address stove-piped responsibilities:
  - Model artifacts will cross organizational / discipline boundaries.
  - Requires a strong interdisciplinary team to support concurrent engineering processes and practices.
MBE Goals

• **The Models are the Design**
  – From Concept to Mission Scenarios to Architecture to Systems Design to Software/Hardware Design & Development to Verification & Validation and finally to Sustainment
  …all based on linked Models across engineering disciplines, with end to end semantic consistency

• **Generate Data Once**
  – …and transform and link as needed

• **Compose Future Systems**
  – Model based composition of components, subsystems, assemblies, test artifacts, etc….all linked, query able and managed under configuration control
  – Emphasis on model libraries and patterns for re-use across Product Line Engineering environments
Our Approach - Integrated Models & Methodologies

• Linked Data Architecture
• Tool Agnostic
• Leverage integration standards
  – Open Service Lifecycle Collaboration (OSLC)
  – Resource Descriptor Framework (RDF)
  – Modelica
  – Service Oriented Architecture (SOA)
  – Functional Mockup Interface (FMI)
  – Base Object Model (BOM)
  – Standard for Exchange of Product Data (STEP) / AP233
• MBE Data Model
  – What we want to link
  – Attributes of what we link
Lessons Learned – Model Linking

• Our engineers want to work in their own comfortable modeling environments, so our team needed to provide a (very) user friendly approach to enable linking of cross-domain models
• We could not find a “reusable” data model that would adequately represent our model based enterprise
• Use of RDF as common denominator for model linking
  – Also enables use of many open source semantic tools
• Building plumbing is hard and not very rewarding
Future Directions – Model Linking

• Work with our tool vendors and standards organization to promote multi-discipline model linking
• Continue to experiment through our IMMERSE environment as a means to influence development of commercial solutions
• Working Semantics through technology and process
• Reasoning and Visualization
Summary

- Achieving widespread adoption of MBE in an organization is challenging
  - New processes, tools, and approaches to learn
  - Legacy data to leverage
  - Critical need to show return on investment

- Automation provides a way to help “get over the MBE Adoption Mountain”
  - Get started quickly by building a core set of model artifacts from existing documents
  - Focus on automation to support robust multi-disciplinary data linking to ensure ROI benefits can quickly realized

- Raytheon is focused on improving life cycle productivity through use of MBE methods