SysML,
It’s Coming – Are You Prepared?

Presentation for George Mason University

Shana L. Lloyd
The Aerospace Corporation
703-324-8877
Shana.l.lloyd@aero.org
Outline

- Introduction
- SysML Background
- Problem Description
- Work to be Done
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Introduction
Introduction

- SEOR Master’s end-of-program project topic for spring 2006 graduates
- The Aerospace Corporation supports system architecture efforts for space systems.
- Desire SEOR MS project to help determine if our customers, National Security Space programs, should begin using SysML and where it is, or is not, appropriate
SysML Background
Background

- The SE community is moving from a document-centric approach to a **model-driven** approach
  - Need integration of SE models with other discipline-specific models (software, hardware, simulation & analysis, etc.)
- Unified Modeling Language (UML) was designed for Software Engineers
  - Lacks all of the mechanisms needed for Systems Engineers
“SysML is a general-purpose graphical modeling language for specifying, analyzing, designing and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities.”
What is UML?

- **Unified Modeling Language (UML)**
  - Object modeling and specification language used in software engineering
  - Object Management Group (OMG) manages and maintains UML

- **Goals of UML**
  - Provide a method of consistent and effective communication among software engineers
  - Provide a way to understand software designs without code or psuedocode
  - Specify, visualize, and document software designs
  - Raise the level of abstraction to focus on system aspects rather than implementation details
  - Provide multiple views of the system
Modeling in UML

What can you model in UML?

- **Structures**
  - Captures the physical & compositional structure of the system
  - E.g. Class Diagrams & Deployment Diagrams

- **Behaviors**
  - Captures the high level behavior of the system
  - E.g. Use Cases & Activity Diagrams

- **Interactions**
  - Captures the details behind the behavior of the system
  - E.g. Sequence Diagrams, Collaboration Diagrams and Timing Diagrams
OMG is leading the SysML Effort

Who is OMG?
- International software consortium established in 1989
- Members include vendors, developers, and end users

Mission
- “To help computer users solve enterprise integration problems by supplying open, vendor-neutral portability, interoperability and reusability specifications based on Model Driven Architecture (MDA).”

Established Standards
- Common Object Request Broker Architecture (CORBA)
- Unified Modeling Language (UML)
- Meta-Object Facility (MOF)
- And more
Model Driven Architecture (MDA)

- **Purpose of Model Driven Architecture**
  - Separate the specification of system functionality from specification of implementation (i.e. a specific technology platform)

- **Concepts of MDA**
  1. **Model**: presentation of a function, structure, and/or behavior of a system
  2. **Platform**: a subsystem that provides functionality through interfaces and usage patterns that any system can use without knowing the details of how that functionality is implemented
  3. **Platform Independent Model (PIM)**: A system model that contains no platform-specific information
  4. **Platform Specific Model (PSM)**: A system model that includes technology and platform-specific information
  5. **Mapping**: Transforming the elements of one model to another model
INCOSE

- International Council on Systems Engineering (INCOSE)
  - “International professional society for systems engineers whose mission is to foster the definition, understanding, and practice of world class systems engineering in industry, academia, and government.”
  - Non-profit membership organization founded in 1990.
  - Promotes an interdisciplinary approach to enable the realization of systems

- Goals
  - Promote collaboration in education and research
  - Establish professional standards, handbooks & guidelines
  - Improve professional status of SE
  - Encourage government and industry support
Request for Proposal (RFP) Background

- Decision to pursue UML for systems engineering made at INCOSE International Workshop in January 2001
- Memorandum of Understanding between OMG & INCOSE signed
- Systems Engineering Domains Special Interest Group (SE DSIG) chartered
- SE DSIG Kickoff Meeting Sept. 2001

SE DSIG Activities
- Issued of Request for Information (RFI)
- Developed Systems Engineering Conceptual Model
- Collaborated with UML 2.0 submission teams
- Developed a requirements analysis
SysML Specification Timeline

2003
- Initial spec (v0.3) presented to INCOSE International Workshop

2004
- UML for SE RFP issued
- Spec v0.9 submitted to OMG
- Initial submission to OMG

2005
- Stereotypes & Model Libraries Chapter submitted as an amendment to spec v0.9
- Draft specs submitted
- Multi-vendor demonstration of v0.9 spec presented to INCOSE.

2006
- OMG announces the adoption of OMG SysML
- INCOSE & OMG evaluate submissions
- SysML 1.0 Spec Submitted to OMG

Mar | May | Jan | Feb | Jan | May | July | Aug | Nov | Dec
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2004
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2005
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2006
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SE Conceptual Model

Captures essential concepts of systems engineering in form of a UML model

Used as input for SysML requirements

Top Level Concept Model, Figure 1.
SysML Language Architecture

SysML:
- Reuses a subset of UML 2.0
- Uses UML 2.0 profile mechanisms to specify extensions for SysML

UML reused by SysML

UML not required by SysML

UML

SysML

SysML extensions to UML

(Have no counterpart in UML or place UML constructs)
Reuse & Extensions

UML reused for SysML
- Actions
- Activities
- Classes
- General Behavior
- Information Flows
- Interactions
- Models
- Profiles
- State Machines
- Structures
- Use Cases

Extensions to UML
- SysML::Model Elements refactors and extends Kernel
- SysML:: Blocks reuses Composite structures & Model Elements
- SysML::ConstraintBlocks extends Blocks
- SysML::Ports & Flows extends UML Ports
- SysML::Activities extends UML Activities
- SysML::Allocations extends UML dependencies
- SysML::Requirements extends Classes and dependencies
Four Pillars of SysML

1. Structure

2. Behavior

3. Requirements

4. Parametrics

Note that the Package and Use Case diagrams are not shown in this example, but are respectively part of the structure and behavior pillars.
## SysML Summary

<table>
<thead>
<tr>
<th>View</th>
<th>Major Extensions</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>Model Elements</td>
<td>Standard way to capture views and design decisions</td>
</tr>
<tr>
<td>Blocks</td>
<td></td>
<td>Flexibility to model non-software components with custom properties</td>
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<tr>
<td>Ports and Flows</td>
<td></td>
<td>Differentiate between what could and what actually does travel through a port</td>
</tr>
<tr>
<td>Constraint Blocks</td>
<td></td>
<td>Ability to integrate analysis in designs</td>
</tr>
<tr>
<td>Behavioral</td>
<td>New Activity Diagram</td>
<td>More control over activities, ability to model continuous streams and path probability</td>
</tr>
<tr>
<td>Stereotypes</td>
<td></td>
<td>New stereotypes for easily behavior classification</td>
</tr>
<tr>
<td>Crosscutting</td>
<td>Allocations</td>
<td>More flexible mapping capabilities</td>
</tr>
<tr>
<td>Requirements</td>
<td></td>
<td>Ability to model requirements, their relationships, and links back to the design diagrams</td>
</tr>
</tbody>
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Available SysML Modeling Tools

- **ARTiSAN Studio** by ARTiSAN Software
- **SysML Toolkit** by EmbeddedPlus
  - 3rd Party Plug-in to IBM Rational Suite
- **TAU G2** by Telelogic
  - Telelogic recently acquired competitor I-Logix
- **Enterprise Architect** by Sparx Systems
Problem Description
Problem Description

- System Engineering community moving from a document-intensive approach to a model-driven one
- SE community needs a standard modeling language
  - Currently using in practice multiple languages
    - Ex: Core, Popkin, PowerPoint cartoons
- OMG just adopted the specification for SysML
  - UML-based modeling language for systems engineering
  - Envisioned to become the standard modeling language for SE
- SysML should integrate with models from other disciplines
  - Especially software since SysML is based heavily on UML
Problem Description (2)

- Many of our customers in National Security Space (NSS) need help with architecture and modeling of both current and future systems
- Customers have a difficult time relating and analyzing system of systems due to currently available methodologies and tools
- Are we sure that SysML, both the specification and tool implementations, is appropriate for use on NSS programs?
  - Want to understand spec limitations and tool capabilities
  - Provide guidance to customers considering using SysML
- How does SysML relate to DODAF?
Work to be Done
Work to be Done this Year

- Model a ground system architecture in SysML
- Objectives:
  - Determine the successes and limitations of the SysML specification
  - Document the tool’s modeling capabilities
  - Develop an executable model to analyze system behavior
    - Either cost or performance or both
  - Perform a trade study of design alternatives
  - Assess how well the SysML models map to UML models
  - Assess the learning curve involved
    - For systems engineers who are used to modeling functional breakdowns
    - For those already familiar with UML and object-oriented design
What You Will Need to Do

- Develop plan, schedule, and deliverables for executing this project
  - Clarify scope
  - To be approved by customer
- Become familiar with space ground systems
- Apply the systems engineering method to
  - Implement the model in SysML
  - Analyze the executable model for design alternatives
- Use Rational System Architect with the SysML plug-in for all the work
What Aerospace Can Do For You

- Provide a case study of a system modeled in Popkin
  - A NASA ground system focused on data archiving
- Meet with you bi-weekly (or more frequently as needed) to assess your progress and answer questions
- Provide access to experienced space system architects/modelers
- Help clarify actual customer use and needs for SysML
- Facilitate the presentation of the results of this effort to professional societies, such as INCOSE
References
Aerospace Contacts

● Shana L. Lloyd
  ■ Engineering Specialist, Software Systems Engineering Department
  ■ 703-324-8877
  ■ Shana.l.lloyd@aero.org

● Julie A. Street
  ■ Senior Member of Technical Staff, Software Systems Engineering Department
  ■ 703-324-8952
  ■ Julie.a.street@aero.org

● Heather N. Howard
  ■ Member of Technical Staff, Systems Architecture, Engineering and Cost Department
  ■ 703-324-0403
  ■ Heather.n.howard@aero.org
References

- **SysML Spec**

- **OMG**
  - [www.omgsysml.org](http://www.omgsysml.org)
  - [www.omg.org](http://www.omg.org)

- **OMG’s SE DSIG**
  - [syseng.omg.org/SysML.htm](http://syseng.omg.org/SysML.htm)

- **OMG’s UML for Systems Engineering RFP**

- **UML Resource Page**
  - [www.uml.org](http://www.uml.org)

- **SysML Tutorial - given at INCOSE 2006 Conference**

- **RFP for UML Profile for DODAF/MODAF**