PURDUE PLM CENTER PROJECT

Daniel DeLaurentis
Director, Center for Integrated Systems in Aerospace
Associate Professor, School of Aeronautics and Astronautics
Overview

• Model-Based Design
• Integration of MBSE with PLM
• Challenges
• Case Studies
Next Generation Design Process

Requirements → Design Space Exploration
Component Libraries → Model Based Design
Construction Rules, Semantic Definitions, Constraints → Formalized Design Language

Metrics:

\[ \text{Performance} = f(W, P, \alpha \ldots) \]

\[ \text{Complexity} = \sum_{s=1}^{c} \left( \sum_{i=1}^{n} W_i \right) + \sum_{k=1}^{m} W_k \]

Verification and Validation
Stochastic Formal Verification

Manufacturing → Model Based Design
Science of Integration

- Current research
  - Requirements Management
  - Process Representation
  - Design Representation (partial)

- More complete lifecycle representations
  - Model-based definition: shape, behavior, and context
  - Connect to simulation and analysis tools

* Nate Hartman, Director, Purdue Center for Product Life Cycle Management

The PLM Circle*

*Purdue College of Technology*
Example: Integration Across Hierarchy

- Decisions on integration exist at multiple levels (e.g., material-components-engine-aircraft)
  - Greater opportunity for innovation
  - Greater uncertainty

- More than optimization, need complexity-guided design space exploration
  - Operational profiles and design architectures

- MBSE methods to link design representations to metrics
  - Feed cost and manufacturing projections

Integrated Computational Materials Engineering (ICME)

Challenges

• No clear success stories
• Lack of transition to downstream lifecycle phases and tools
• Just a diagramming tool; impractical for analyzing millions of objects and relationships for integrity
• How to introduce to an existing product?
• Lack of methods to measure impact of MBSE
• Acceptance by regulatory bodies is difficult
Not Just a Diagramming Tool

Case Study 1

- Analyzed similarities and differences in SysML representations and Agent-Based Models
- Proposed a general framework for SysML-ABM Translation
- Demonstration

Creating Executable Agent-Based Models Using SysML

Apoorv Maheshwari, C. Robert Kenley, and Daniel A. DeLaurentis
Purdue University

Translation Framework
Demonstration

Case Study 1

Logical

Physical

Symbol | Aircraft Mode
---|---
| Normal Mode
| Receiving ADS-B data
| Fault in ADS-B In

ADS-B In Range
Separation Bubble
Potential Success Story

Case Study 2

- **Reference Model for Infusion Pump**

- Model-based representation of a generic infusion pump and a systems engineering process for planning, developing, and obtaining regulatory approval of a medical device

- Demonstration

An infusion pump is a medical device that delivers fluids, such as nutrients and medications, into a patient’s body in controlled amounts.

This work was done in collaboration with INCOSE Biomedical Healthcare Working Group
The above described Product Development Process has also been mapped to ISO 14971:2007 to make it easier to understand for Healthcare Community. The mapping can be found here.
Questions?
Future Work

• Case Study 3 (Ongoing)
  – UAV Design Process Representation
  – Stability Analysis by translating the geometry information to XFLR5

• Possible extension to Flexible UAV
Systems Modeling Language (SysML)

• Four set of viewpoints to define the system
  – Structural – definition of elements
  – Behavioral – interaction, architecture
  – Requirements – requirement management (checklist)
  – Parametric – constraints via logical and mathematical expressions

• Network sets
  – Logical
    • Exchange of information between systems
    • What information is transferred between systems
  – Physical
    • Connectivity of systems
    • Over which physical paths the information is transferred