PURDUE PLM CENTER PROJECT

Daniel DeLaurentis

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

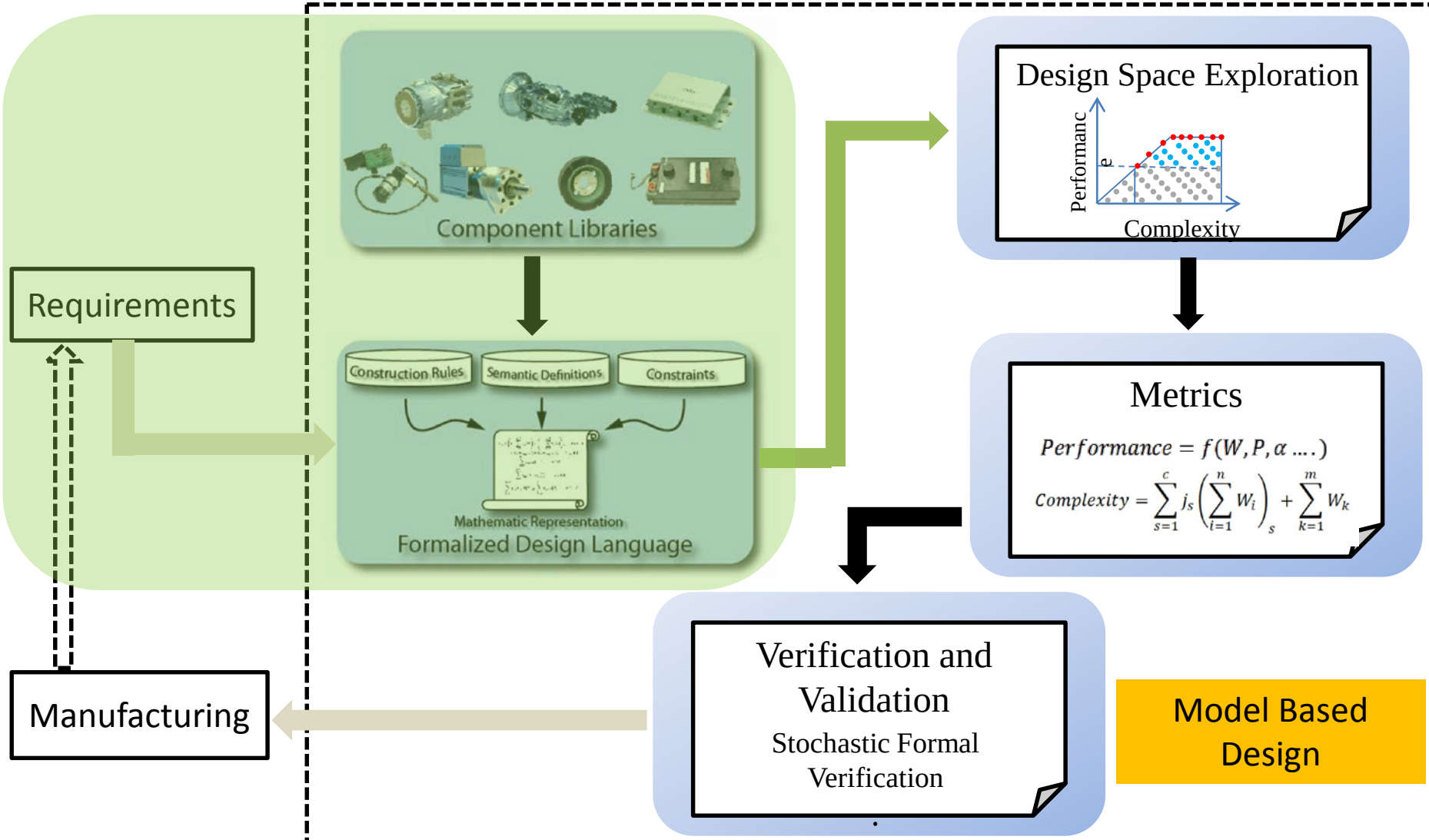
PRODUCT LIFECYCLE MANAGEMENT
CENTER OF EXCELLENCE

PURDUE
COLLEGE OF TECHNOLOGY

Overview

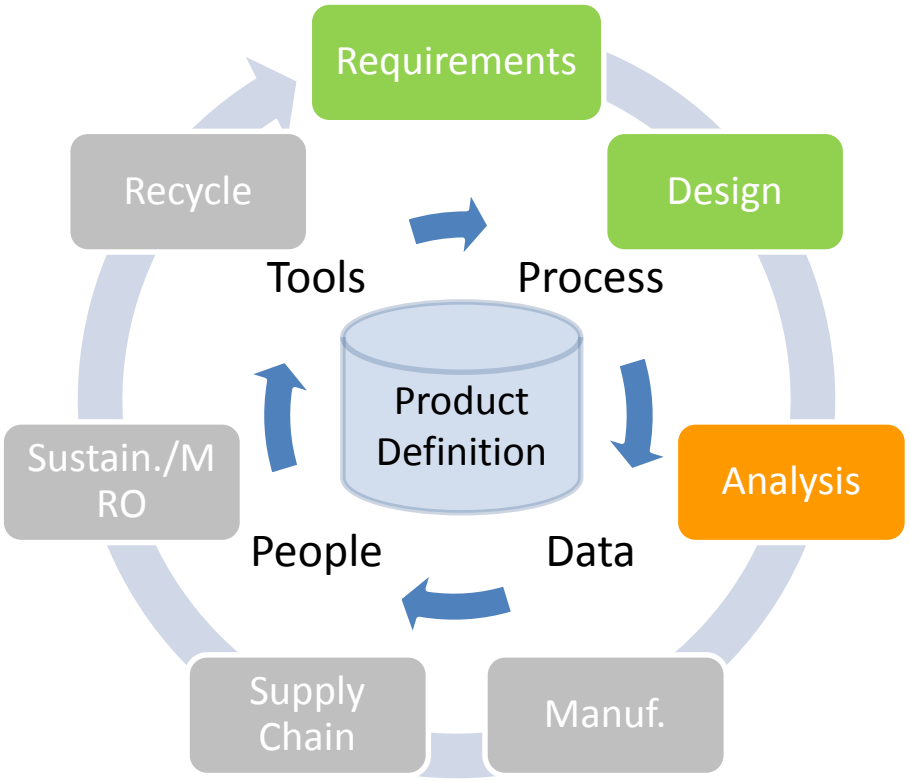
- Model-Based Design
- Integration of MBSE with PLM
- Challenges
- Case Studies

Next Generation Design Process



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

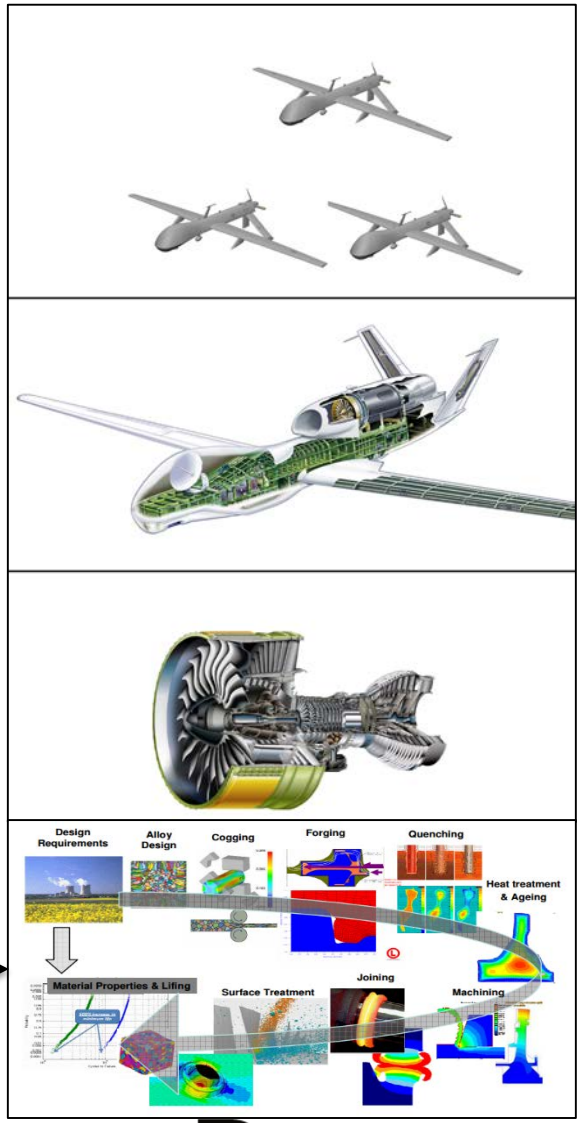


*The PLM Circle**

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

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)

Image source: Engine- http://www.cfmaeroengines.com/img/engines/CFM56-leap-engine.jpg; ICME- "Application of ICME to Turbine Engine Component Design Optimization" http://arc.aiaa.org/doi/abs/10.2514/6.2011-1738

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

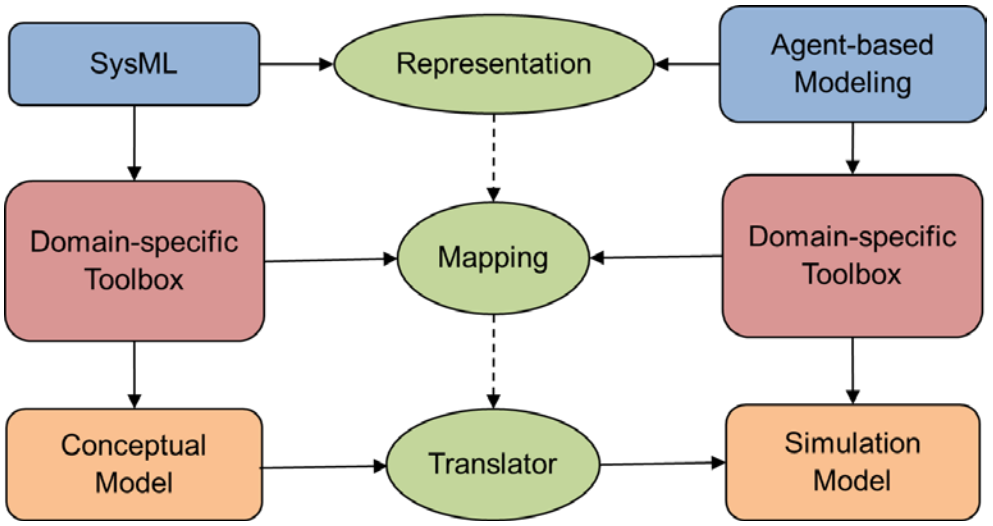
- Analyzed similarities and differences in SysML representations and Agent-Based Models
- Proposed a general framework for SysML-ABM Translation
- Demonstration

25th Annual INCOSE International Symposium (IS2015)
Bellevue, WA, July 13 – July 16, 2015

Creating Executable Agent-Based Models Using SysML

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

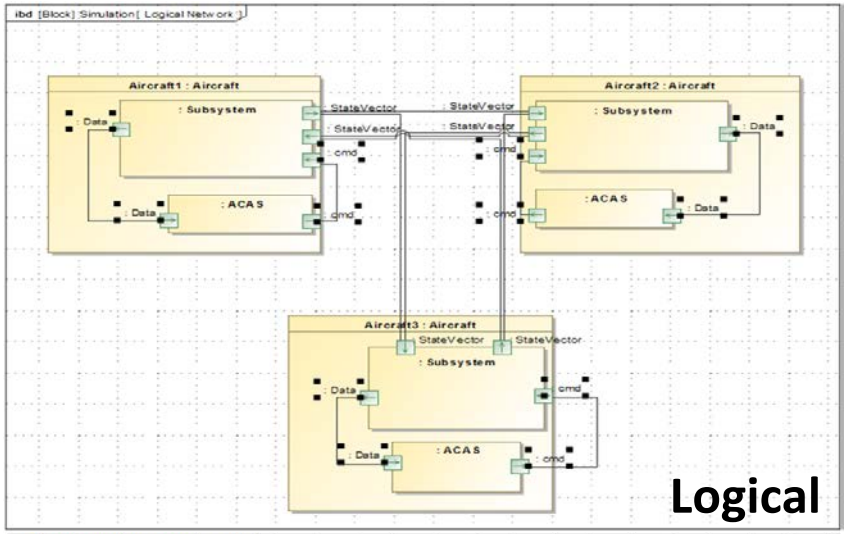
Purdue University

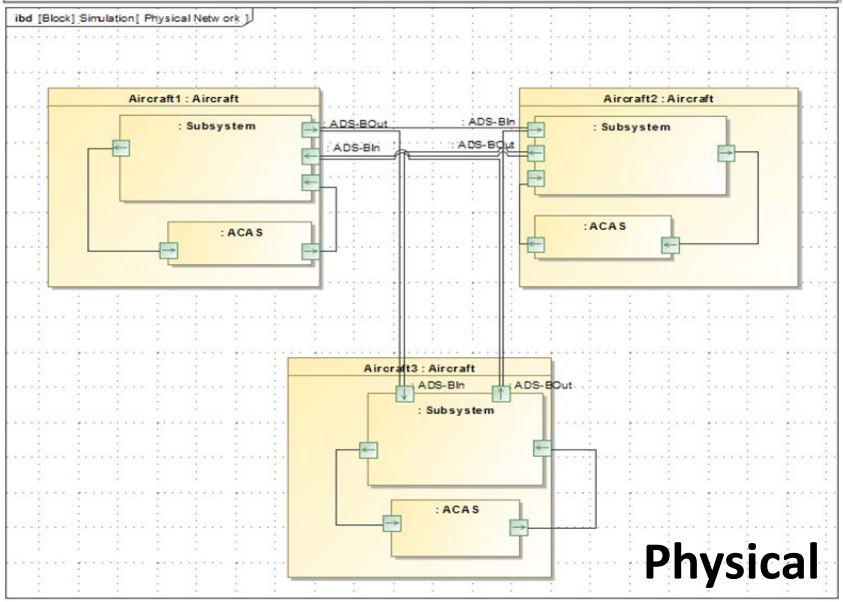


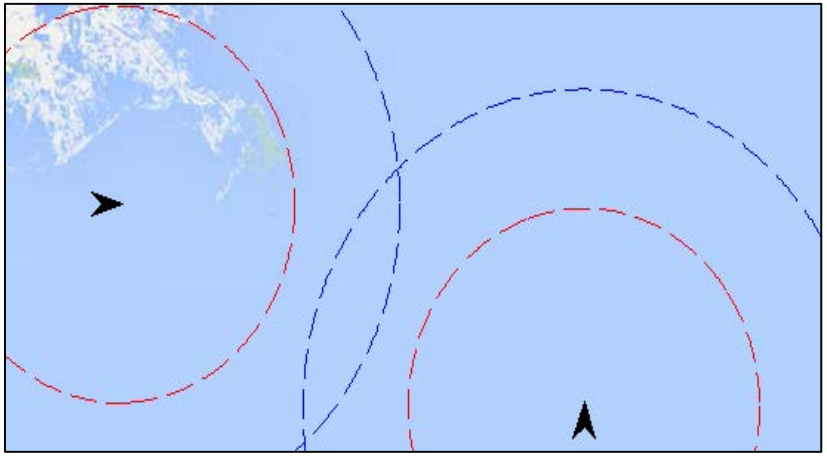
Translation Framework

Demonstration

Case Study 1







ADS-B In Range
Separation Bubble

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

Potential Success Story

Case Study 2

- **Reference Model for Infusion Pump**

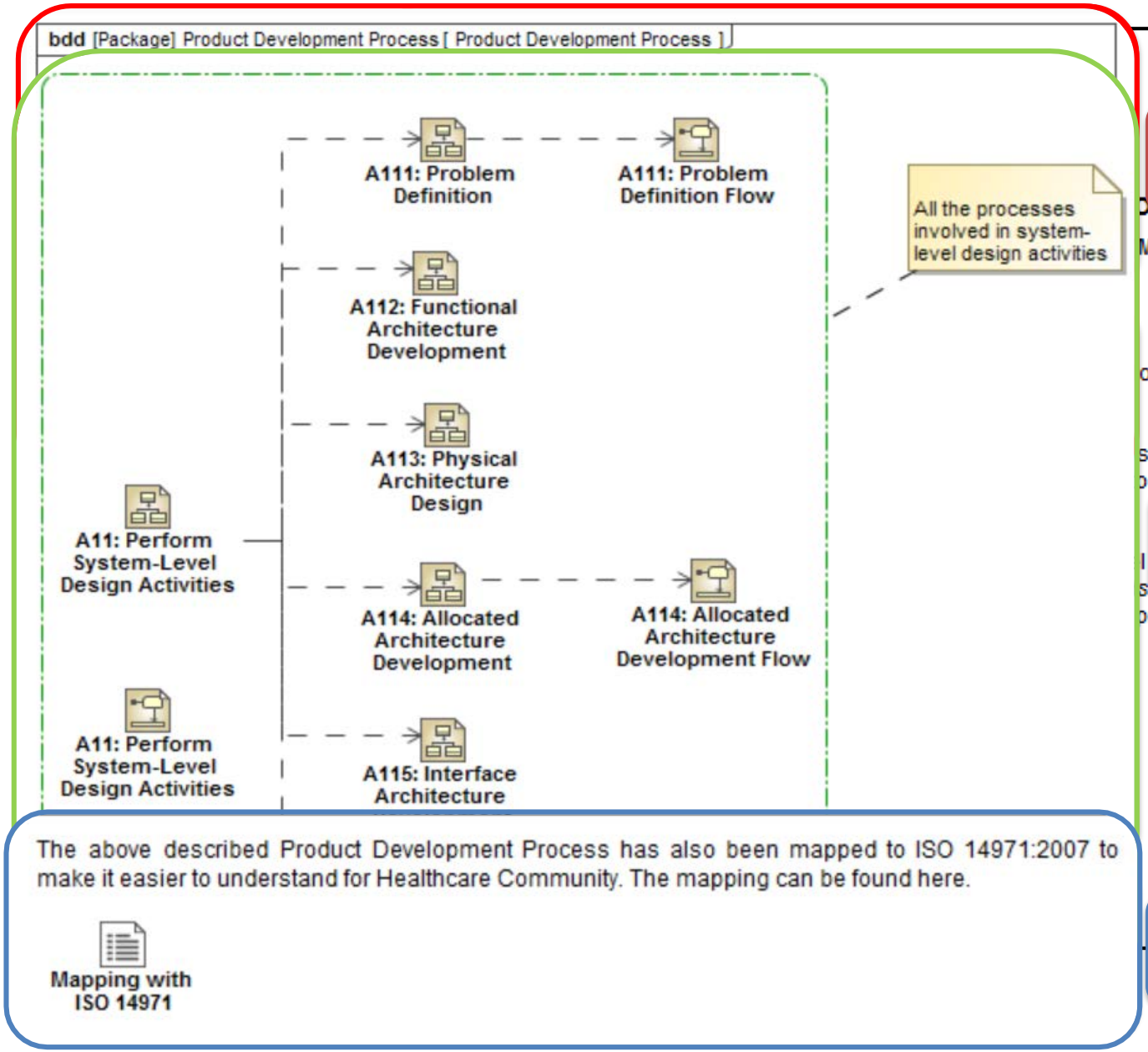
- Model-based representation of a generic infusion pump and a systems engineering process for planning, developing, and obtaining regulatory approval of a medical device

- 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

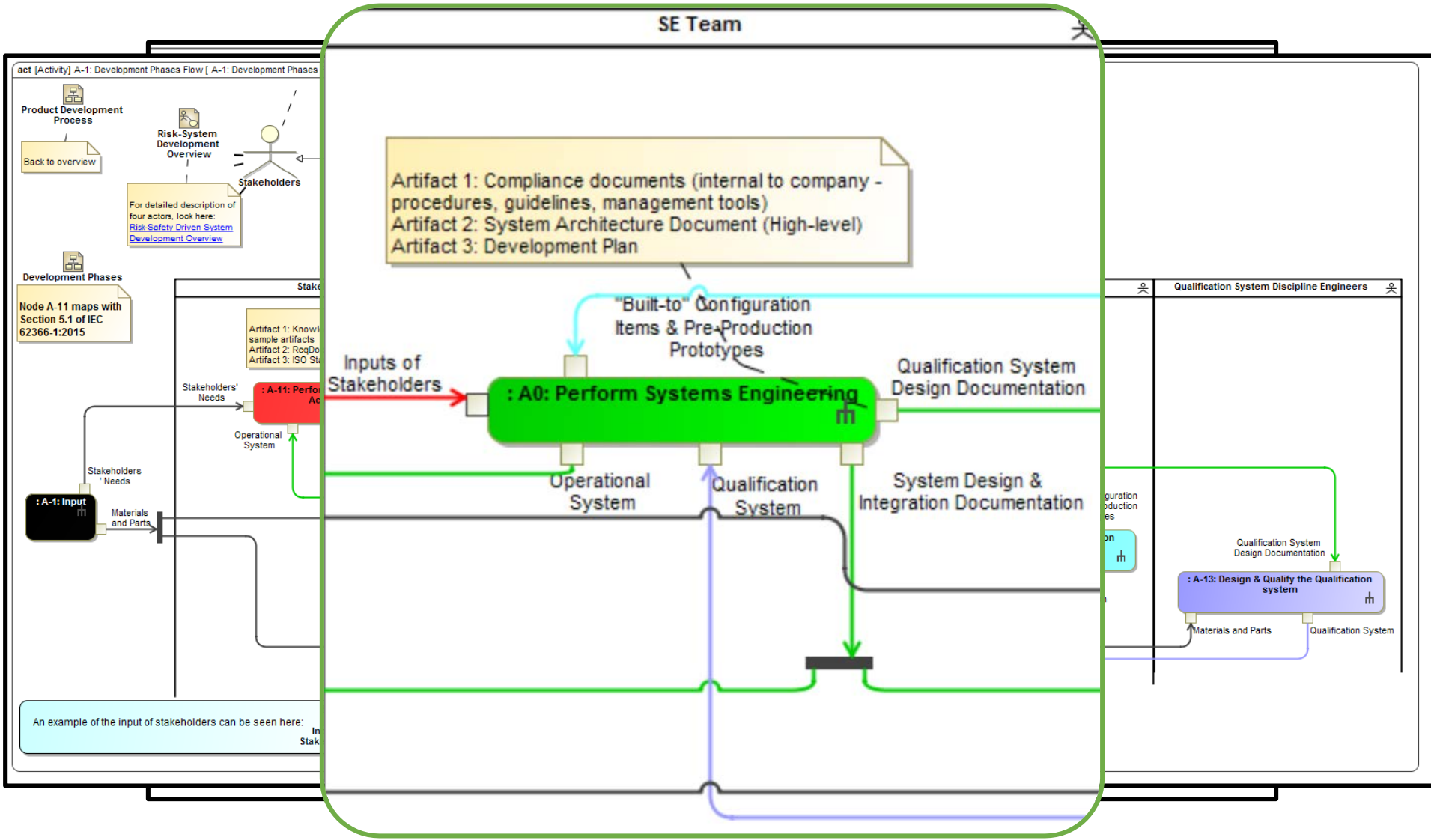
Demonstration



Pre-Systems Engineering Processes

System-level Design Activities

Mapping Information


SE Team
act [Activity] A-1: Development Phases Flow [A-1: Development Phases
Product Development Process
Back to overview
Risk-System Development Overview
Stakeholders
For detailed description of four actors, look here:
Risk-Safety Driven System Development Overview
Development Phases
Node A-11 maps with Section 5.1 of IEC 62366-1:2015
Artifact 1: Compliance documents (internal to company - procedures, guidelines, management tools)
Artifact 2: System Architecture Document (High-level)
Artifact 3: Development Plan
"Built-to" Configuration Items & Pre-Production Prototypes
Inputs of Stakeholders
: A0: Perform Systems Engineering
Qualification System Design Documentation
Operational System
Qualification System
System Design & Integration Documentation
Stakeholders' Needs
: A-11: Perfo
Ac
Operational System
Stakeholders' Needs
: A-1: Input
Materials and Parts
Qualification System Discipline Engineers
Qualification System Design Documentation
: A-13: Design & Qualify the Qualification system
Materials and Parts
Qualification System
An example of the input of stakeholders can be seen here:

Thank You

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