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Utilizing MBSE Patterns to Accelerate System Verification

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Presentation Outline

- Introduction
- Challenges and Opportunities
- MBSE and Patterns
- Application to Verification
- Application Example
- Summary and Conclusions

INCOSE Patterns Working Group

- Formerly the Pattern-Based Systems Engineering (PBSE) Challenge Team
- Advance the availability of model-based System Patterns and related PBSE resources
- Promote the awareness of PBSE models and resources, increasing the availability and successful use of System Models across the life cycle of systems

System Patterns

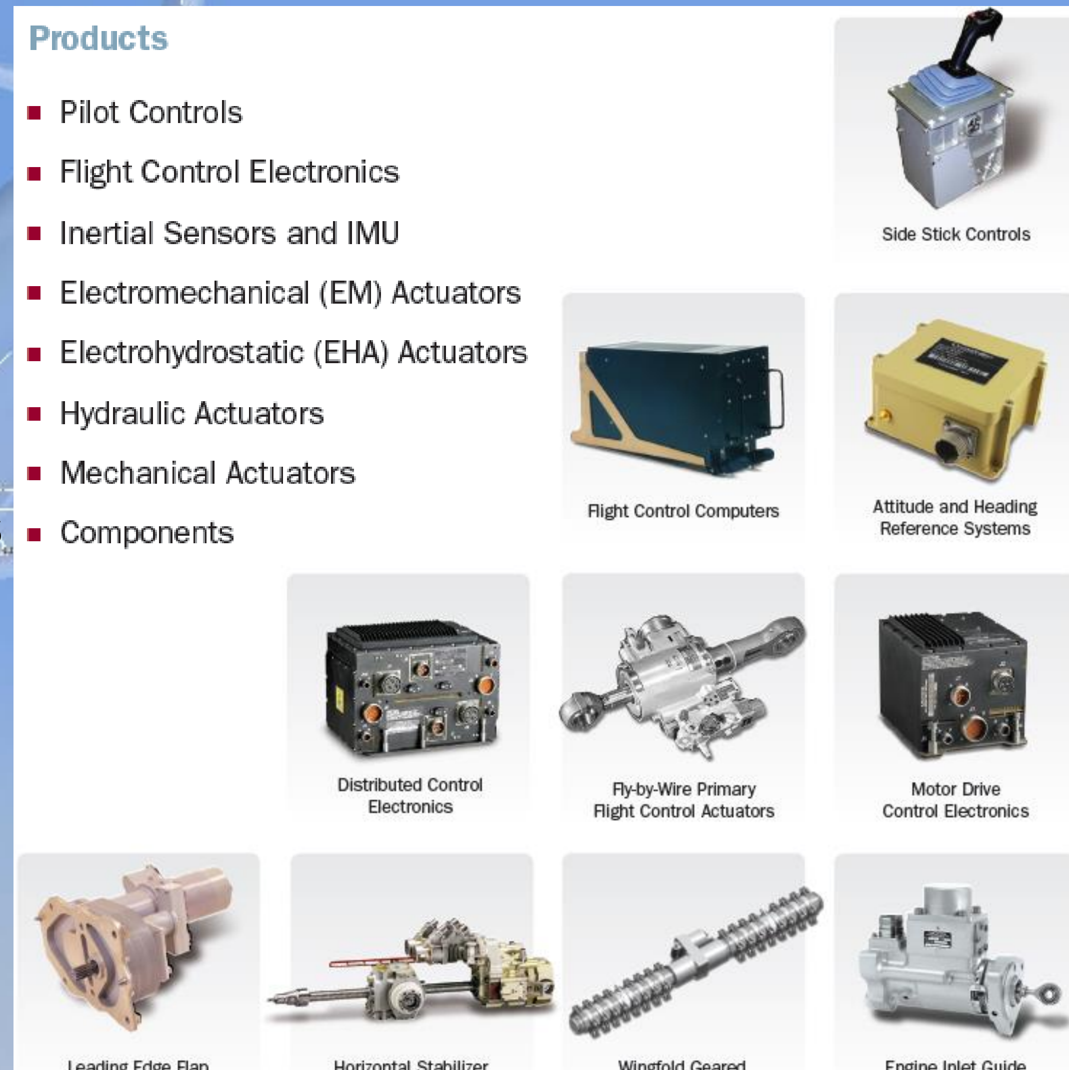
- System Patterns are configurable, re-usable System Models that would otherwise be like those expected and found in the practice of MBSE
- Because they are configurable and re-usable models of families or classes of systems, model-based System Patterns involve some additional methods and disciplines that extend the ideas of MBSE (e.g., Pattern Management, Configuration Rules, model minimality, etc.).

Introduction

- Pattern Based Systems Engineering
  – A disciplined and systematic approach to maximize the effective use of intellectual capital
- MBSE with pattern based methods holds significant promise
- Example: testing of a safety critical aircraft subsystem, namely the flight control actuation system

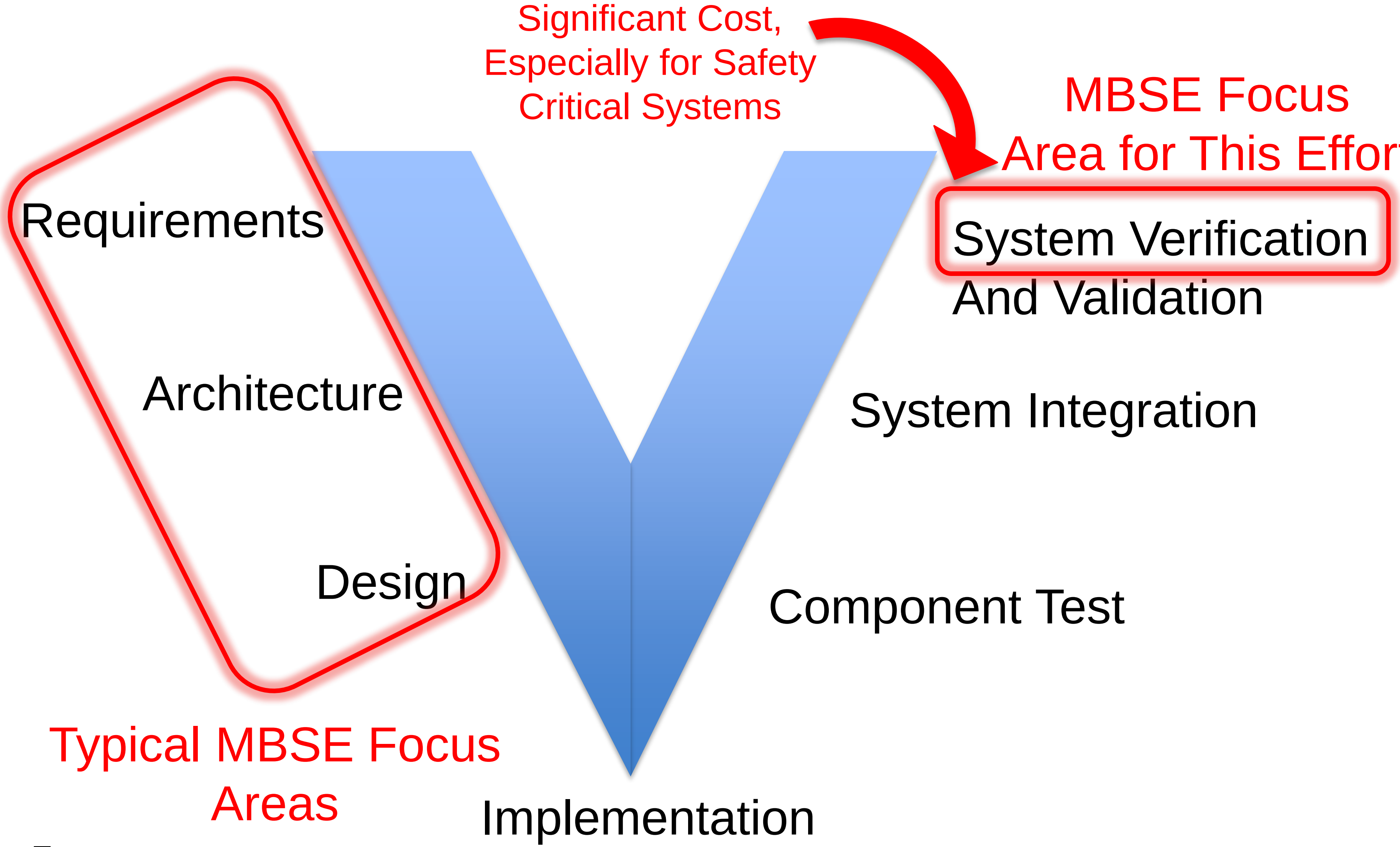
Background

- Moog Aircraft Group provides safety-critical systems and products for a wide variety of airborne applications
  - Primary Flight Controls
  - Secondary Flight Controls
  - Navigation and Guidance
  - Engine Controls
  - Utility Systems



 http://www.moog.com/literature/Aircraft/Moog_AG_Aircraft_Capabilities_Brochure_Jun2012.pdf

Challenges



Significant Cost,
Especially for Safety
Critical Systems
MBSE Focus
Area for This Effort
Requirements
Architecture
Design
System Verification
And Validation
System Integration
Component Test
Implementation
Typical MBSE Focus
Areas

Opportunities

- Cut costs by reducing the testing effort without sacrificing effectiveness
- Move verification activities earlier in the design cycle to help minimize risk
- Take advantage of automation capabilities of modern computer tools

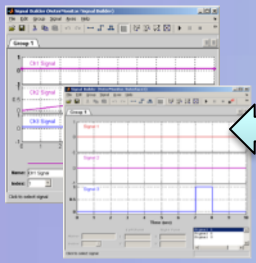
Model-Based Workflow

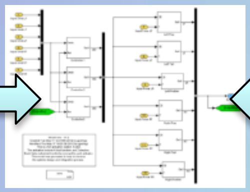
System Design

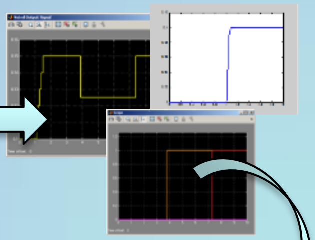
Requirements Based Inputs

Model Based Analysis, Design, and Architecture

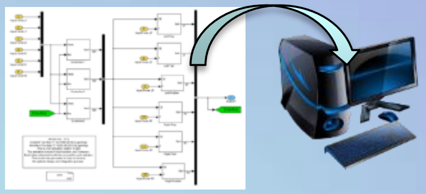
Requirement Derivation and Flowdown

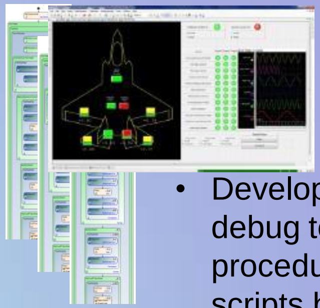






Real-Time Simulation



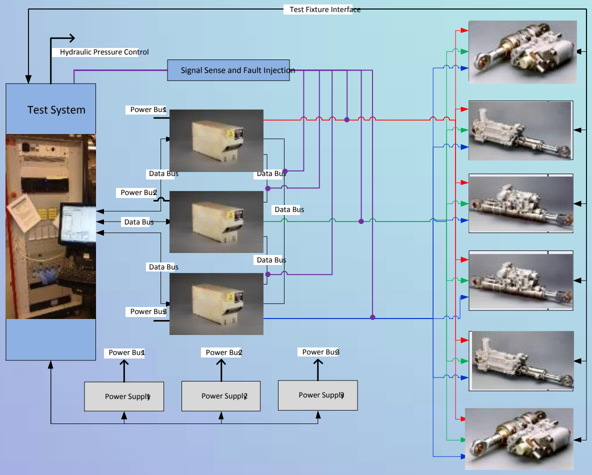


- System model ported to real-time simulator
- Same user interface as test lab
- Simulation allows parallel test development with no lab assets

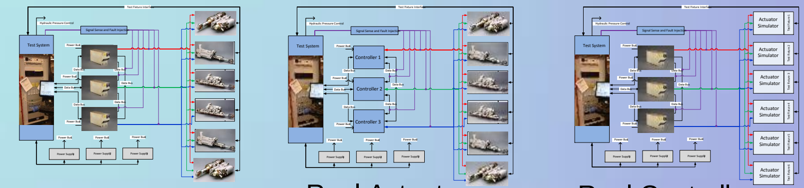
- Develop and debug test procedures and scripts before integration
- Find functional problems early

Formal System Testing

- Utilizes procedures and scripts developed in simulation and dry run in integration
- Formal Verification of requirements
- Modular, scalable lab to accommodate any type of system



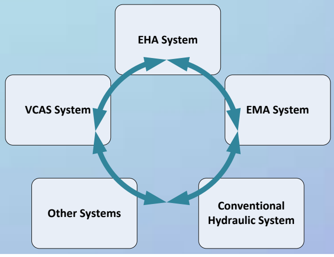
Prototype/Integration Testing



Full System Integration

Real Actuators, Simulated Controllers

Real Controllers, Simulated Actuators



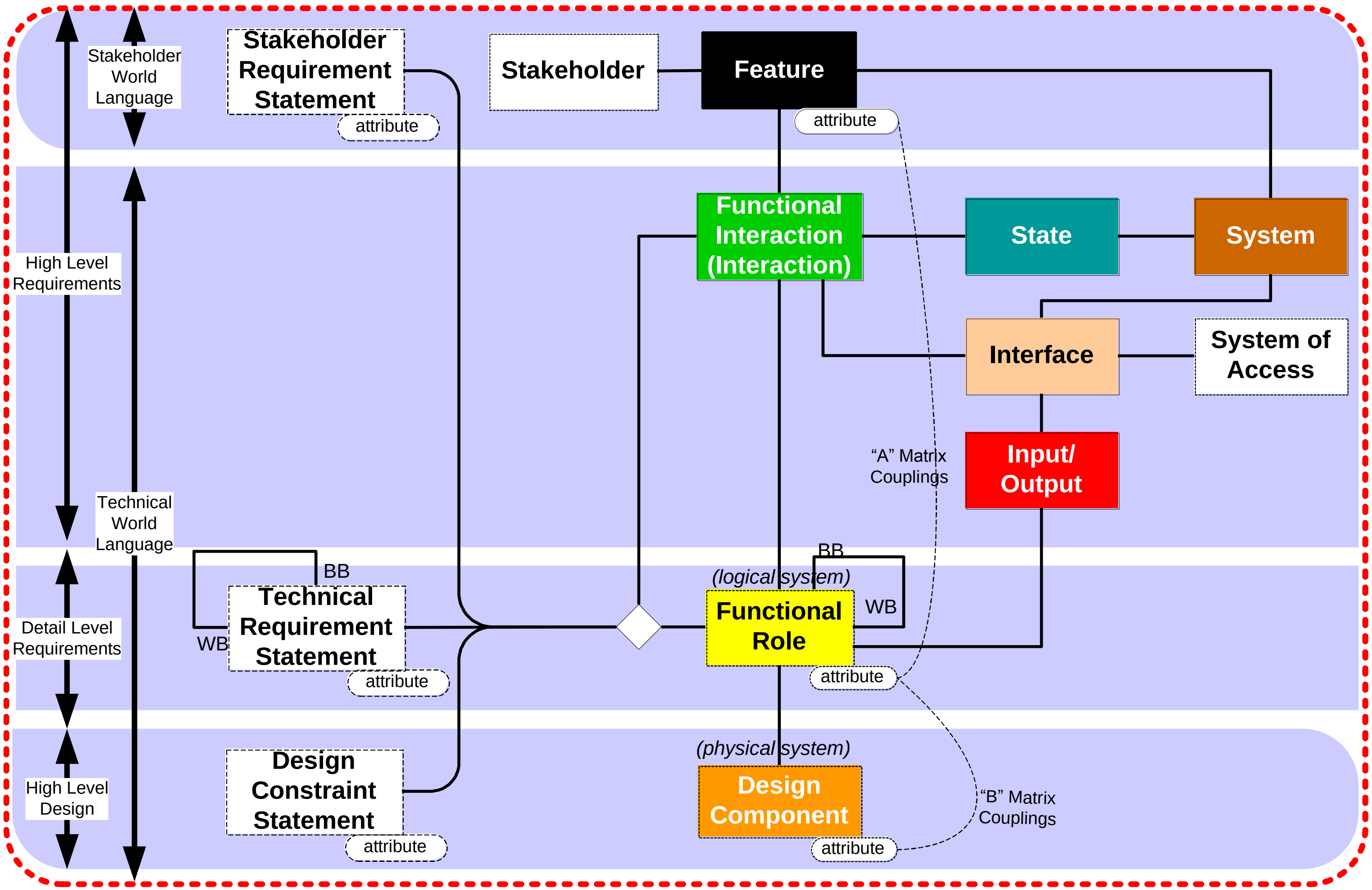
- Common, reconfigurable development and verification lab architecture
- Capable of running with simulations up to full system hardware and anything in between

MBSE and Patterns

- A strong model foundation is needed to develop robust system patterns

- The S*Metamodel is a generic information model that can be used to represent systems
  - Consistent representation
  - Can be mapped to tool of choice
  - Robust data model for representing patterns

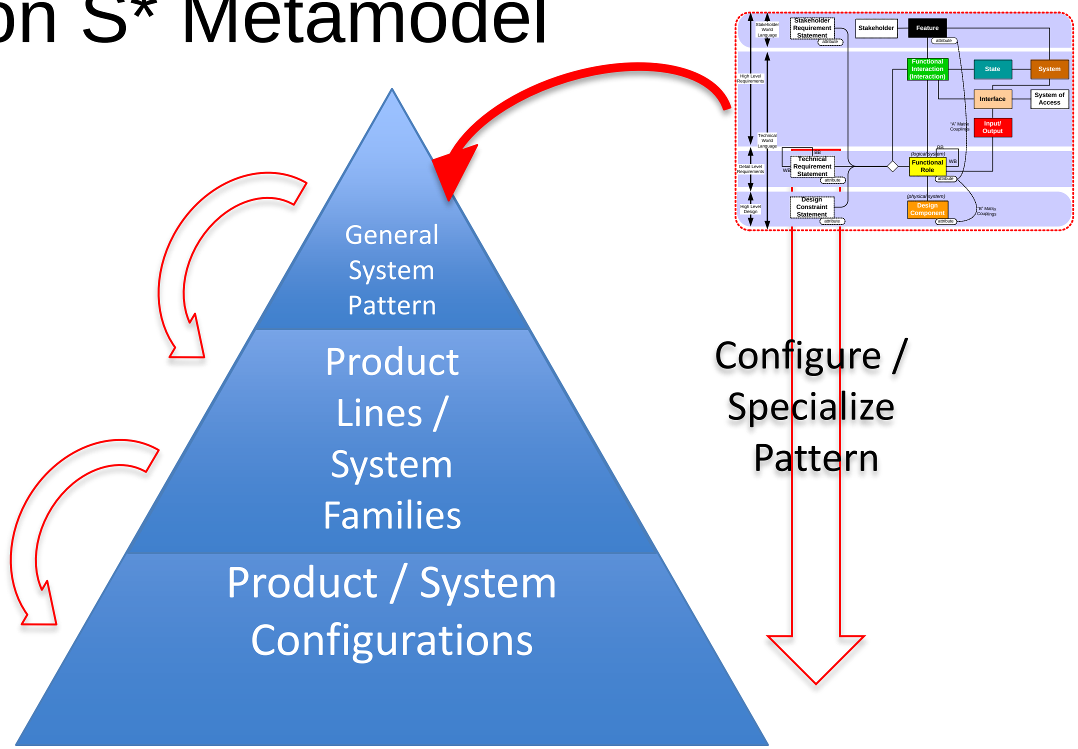
S* Metamodel



A Robust Data Model for Representing Systems

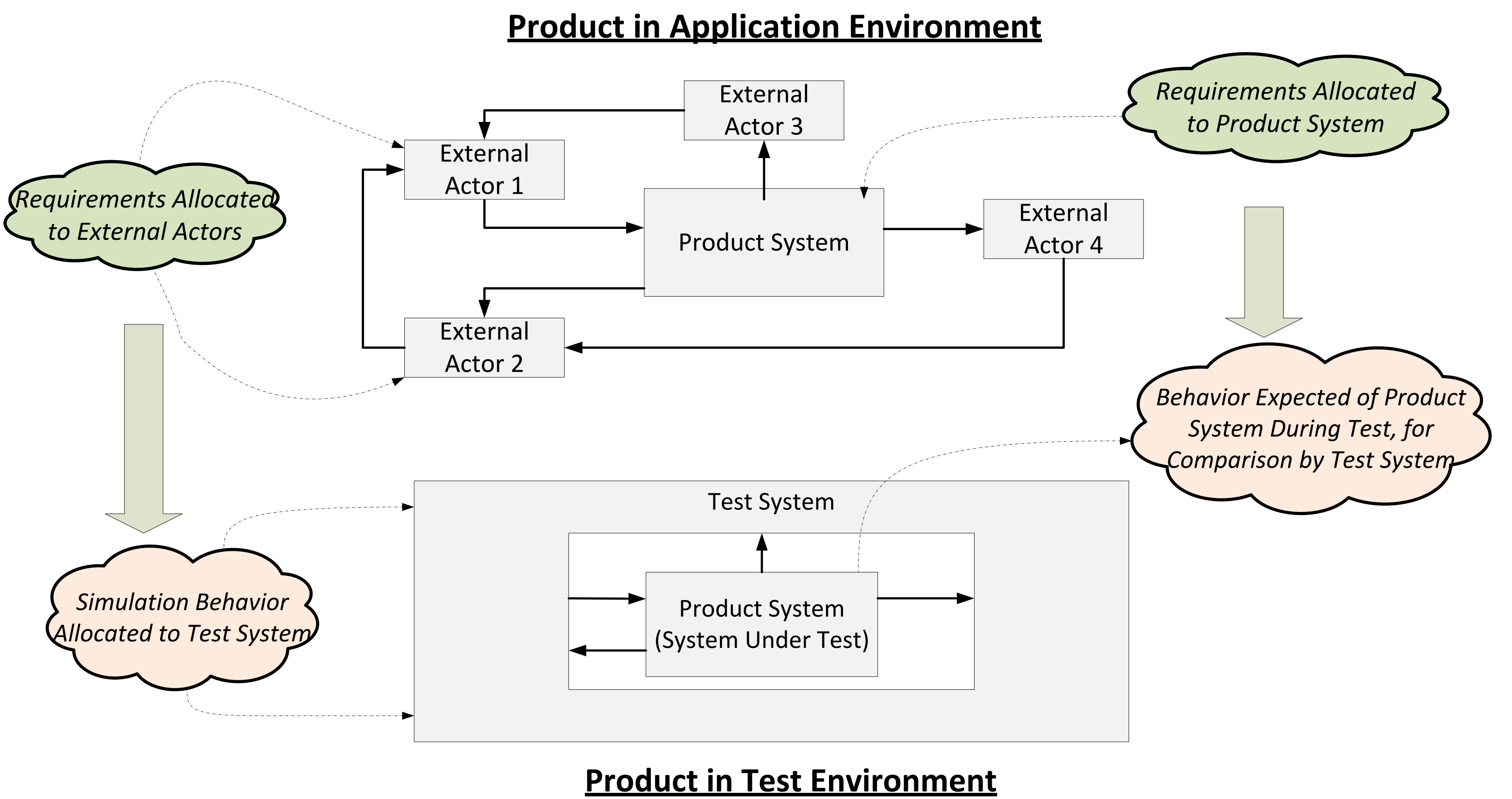
PBSE: Pattern-Based Systems Engineering

- Systems Engineering patterns are reusable, configurable <u>system models</u>
  - – Based on S* Metamodel

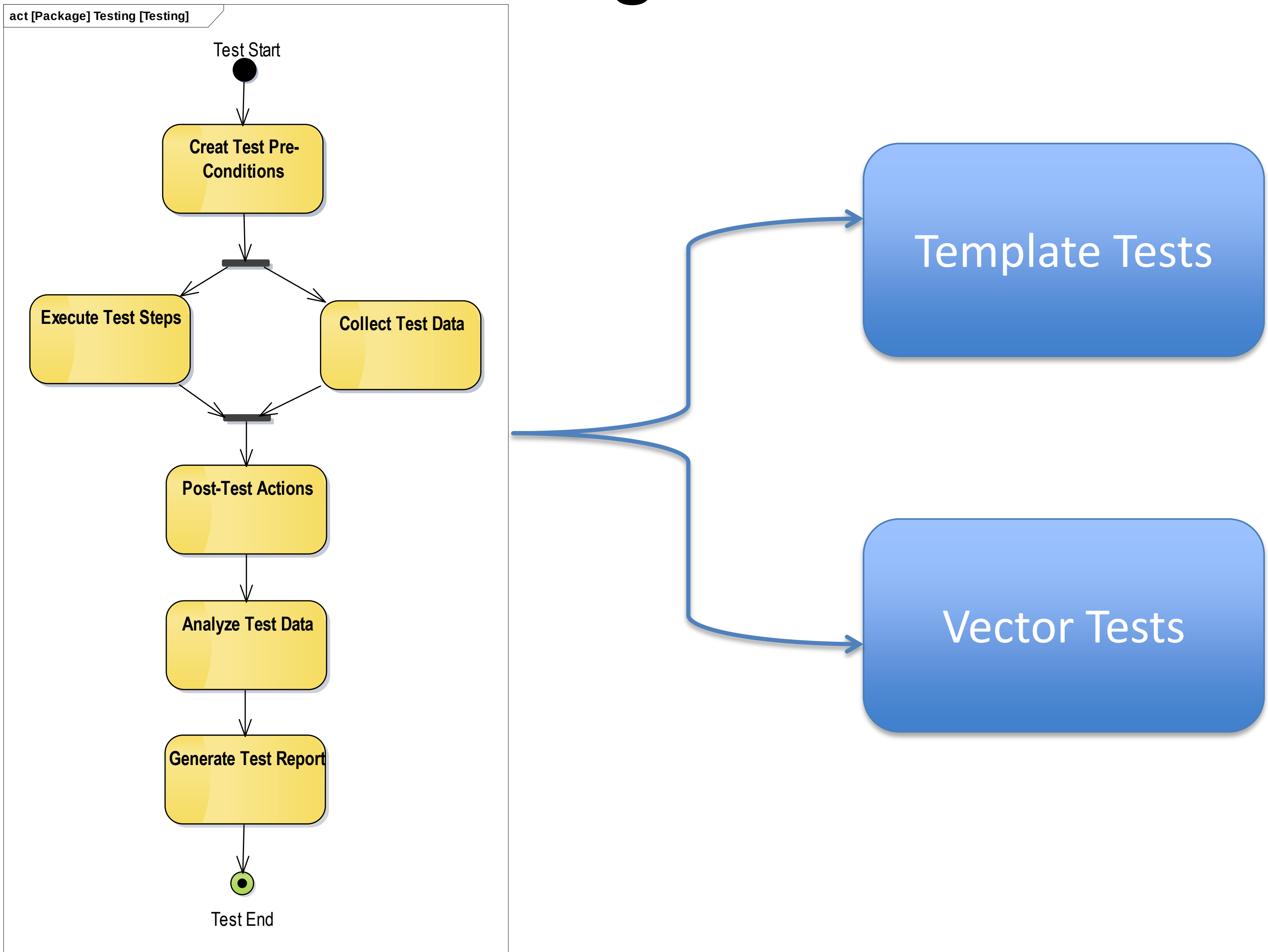


System Pattern Class Hierarchy

MBSE Test Representation



Testing Pattern

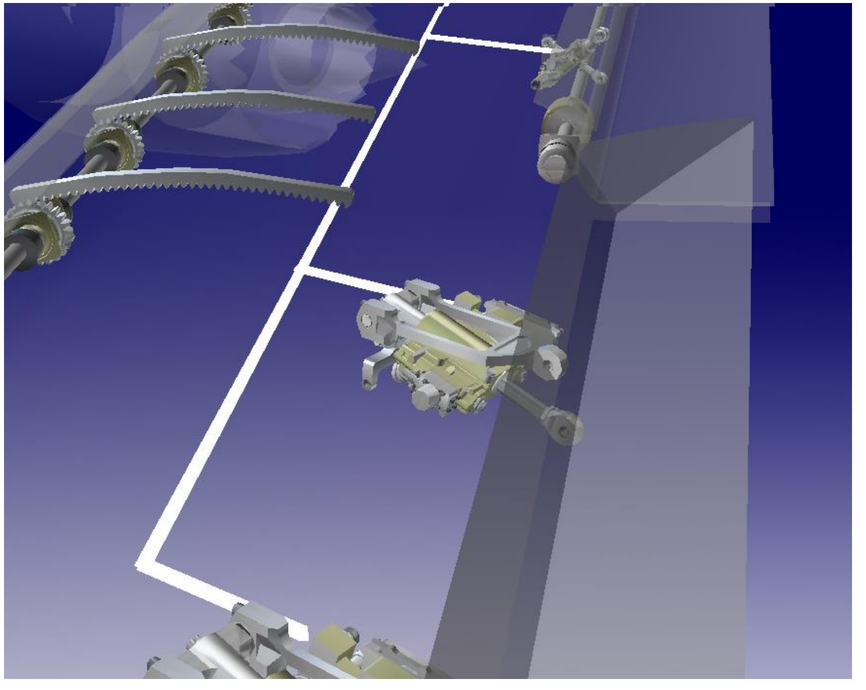


Application Example

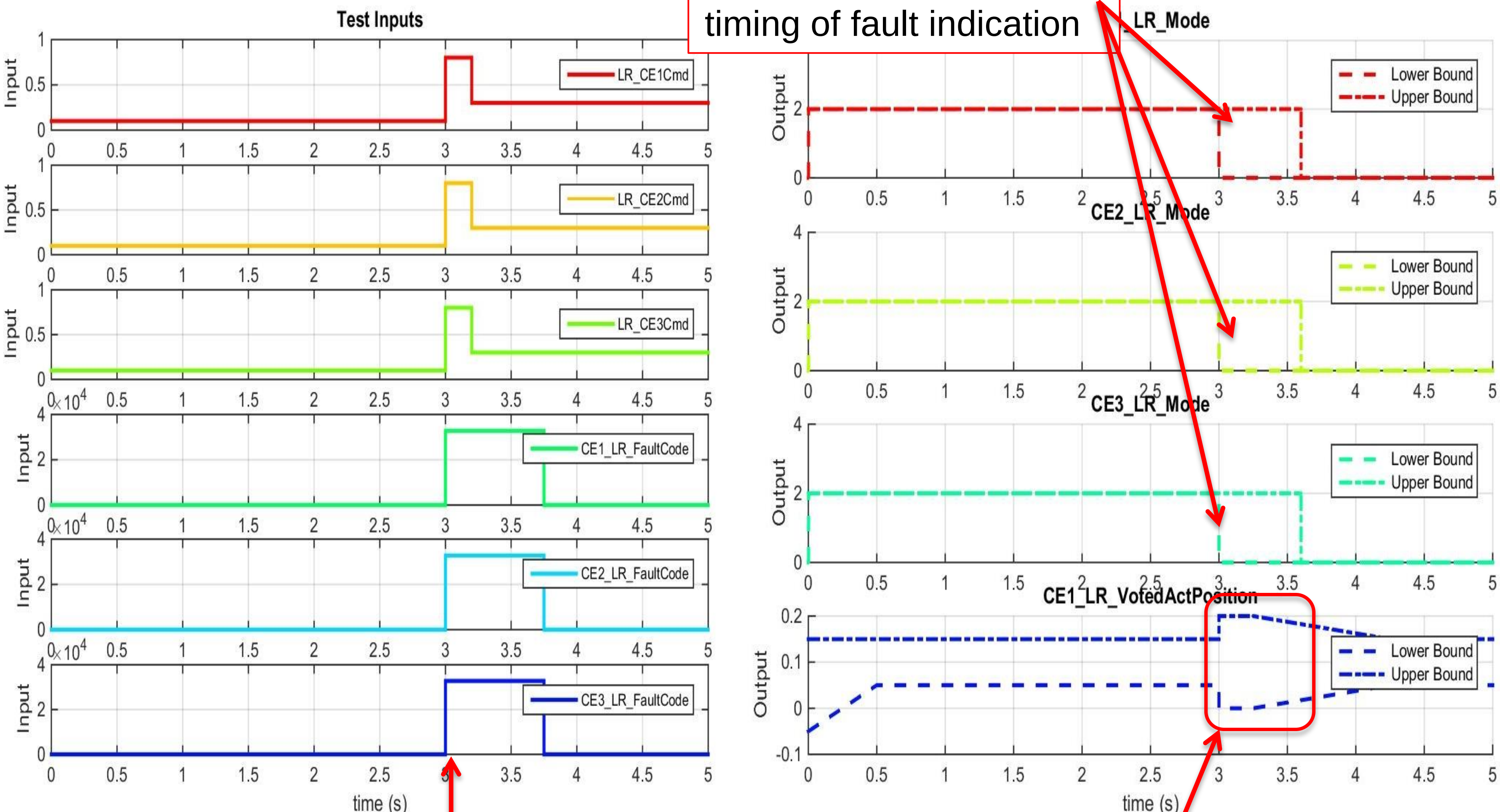
- Scenario
  - Uncommanded motion of a flight control surface (aileron, rudder, etc.) can have catastrophic aircraft effects

- This example is for a test that verifies the system's ability to detect and mitigate a fault condition that causes uncommanded surface motion

Surface Transient



Test Definition

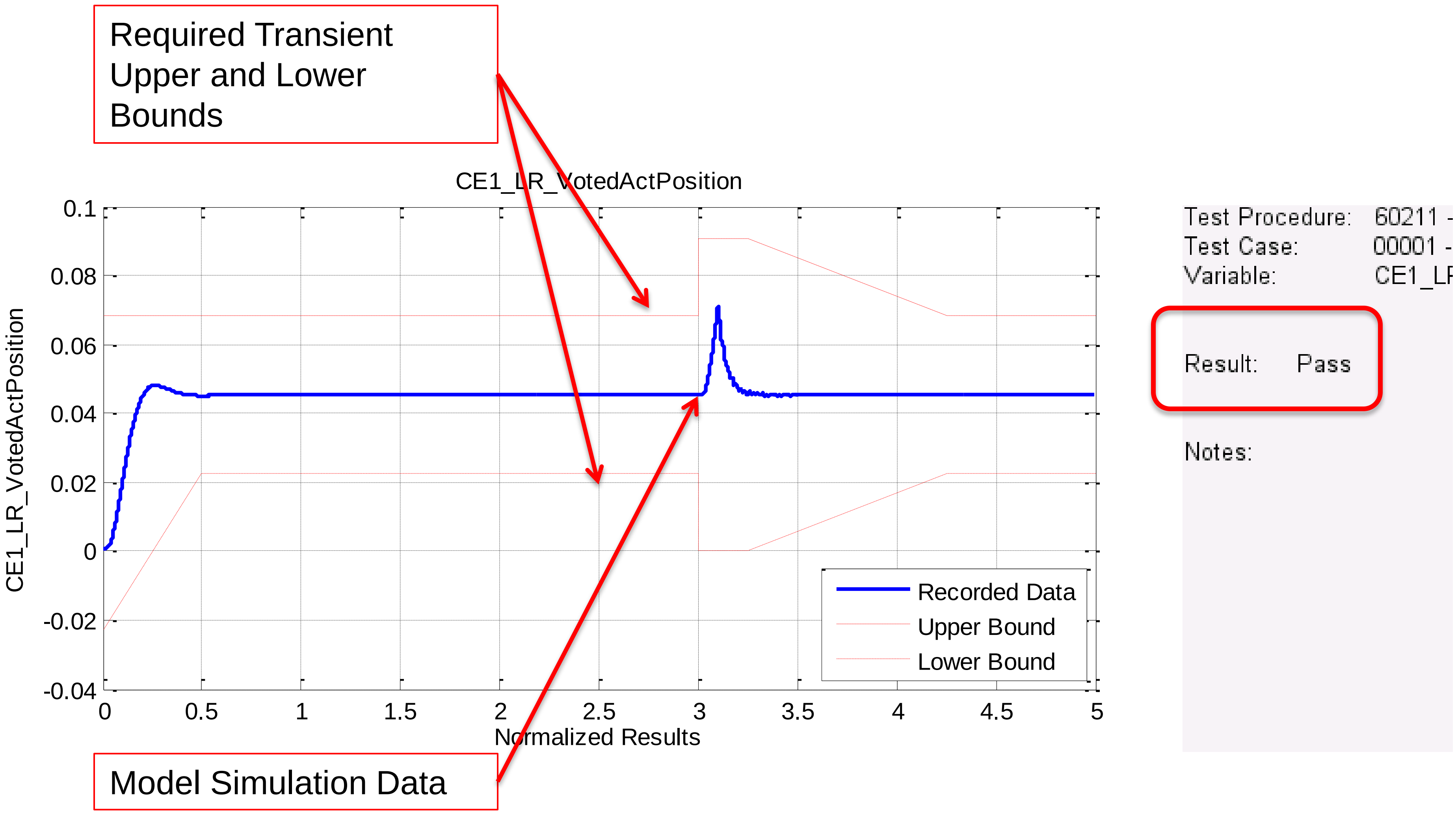


Expected "envelope" for timing of fault indication

Injection of servovalve fault

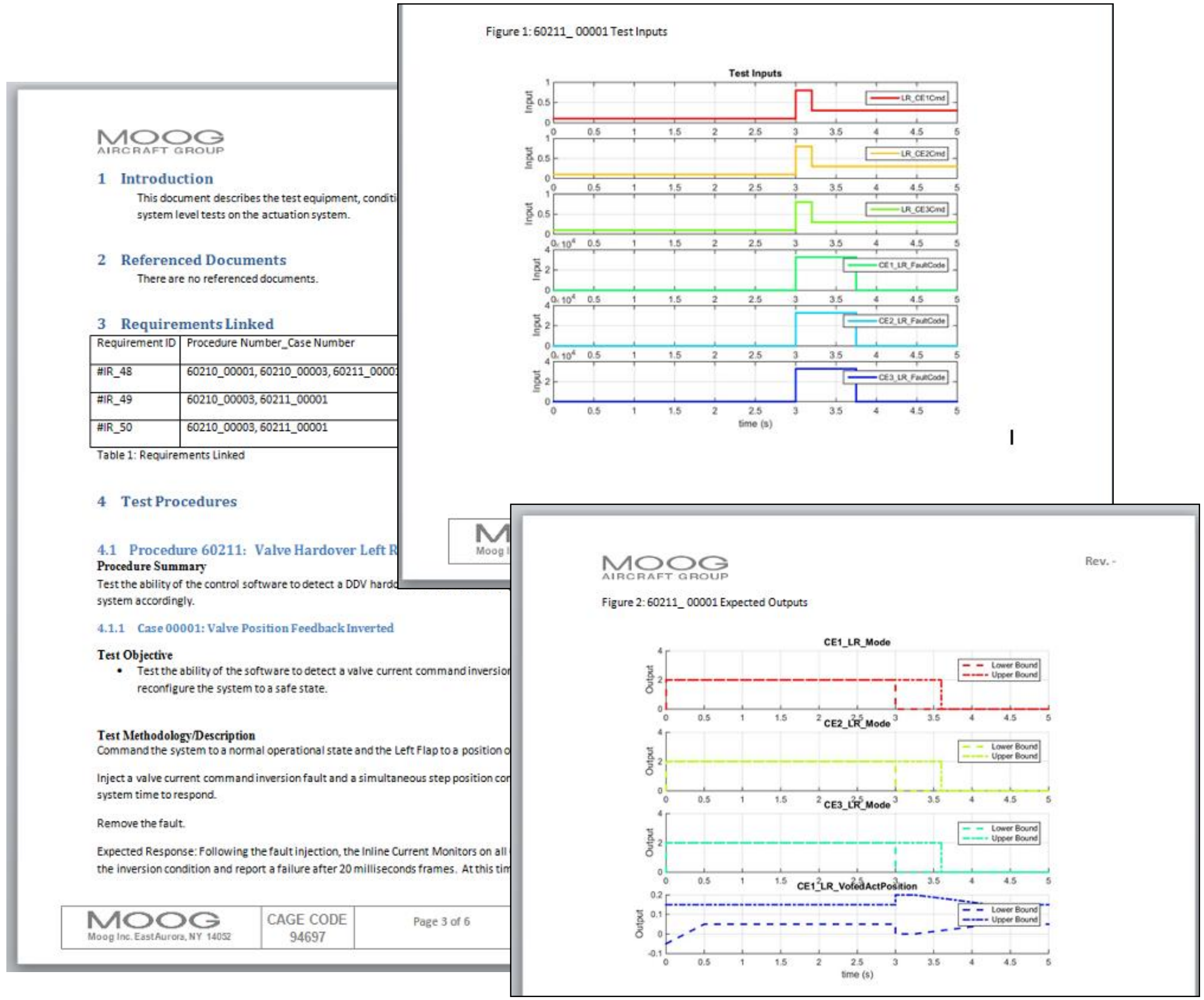
Required bounds for surface transient

Test Simulation



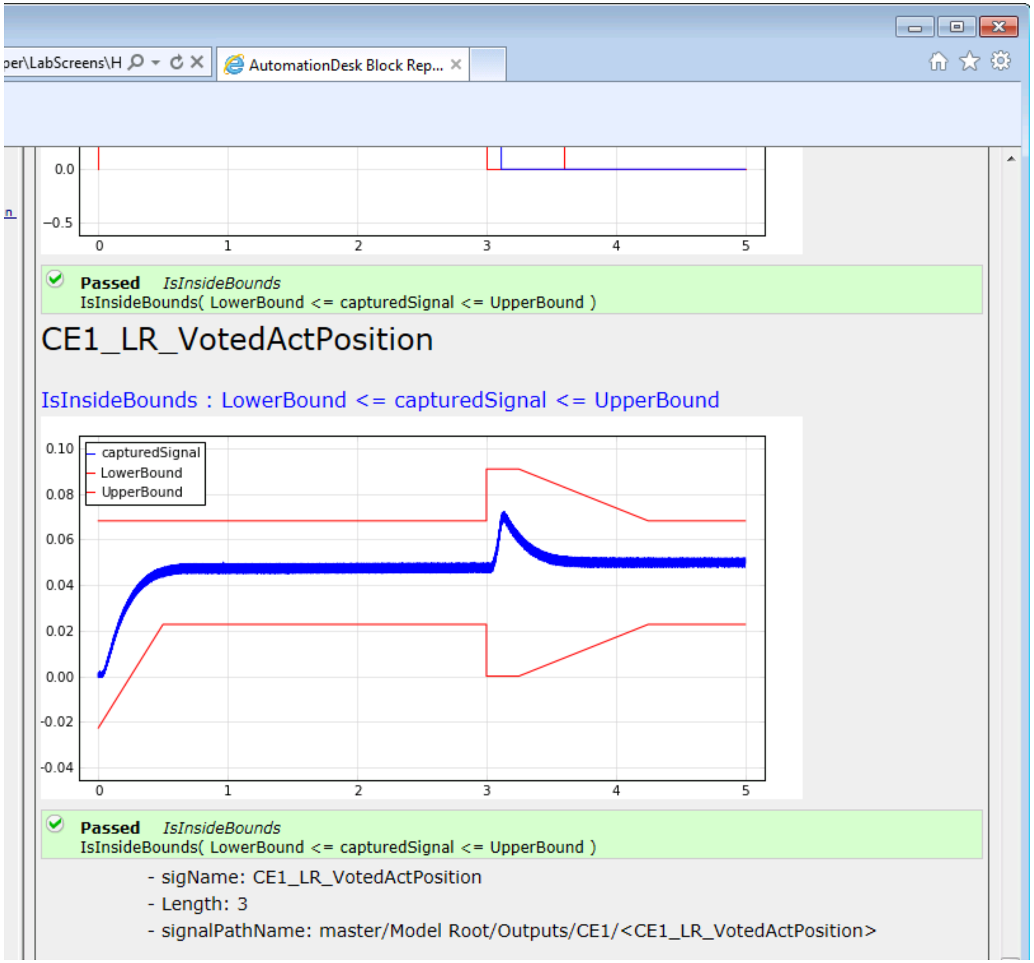
Automated Test Procedure Generation

- Human readable test procedure is generated from test vectors, requirements links, and descriptive metadata



Automated Test Reports

- Vectors translated into a format that is readable by the test system
- Pass/Fail results are generated based on the expected output vectors



Summary and Conclusions

- Applying the presented MBSE methods to verification testing has reduced system testing effort by more than 25%
- The presented MBSE methods provide spatial and temporal flexibility in test development
- Potential exists to realize greater benefits through the application of S* patterns across other areas of the development life cycle

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