Model Based Mission Assurance: Emerging Opportunities for Robotic Systems

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The emergence of Model Based Systems Engineering (MBSE) in a Model Based Engineering framework has created new opportunities to improve effectiveness and efficiencies across the assurance functions. The MBSE environment supports not only system architecture development, but provides for support of Systems Safety, Reliability and Risk Analysis concurrently in the same framework. Linking to detailed design will further improve assurance capabilities to support failures avoidance and mitigation in flight systems. This also is leading new assurance functions including model assurance and management of uncertainty in the modeling environment. Further, the assurance cases, a structured hierarchal argument or model, are emerging as a basis for supporting a comprehensive viewpoint in which to support Model Based Mission Assurance (MBMA).
Model Based Mission Assurance

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MBSE – How does SMA fit in

Assurance products modified to fit into a model based environment

Facilitates and strengthens SMA’s Insight, Oversight, Risk Assessment capabilities, and Technical Authority role

Safety Requirements and Quality Demands

Reliability Models

FMEA & Hazard Analysis
MBMA – Model Based Mission Assurance

![Diagram depicting MBMA flow]
### Example - MBSE FMEA

**SysML Models**

**Magic Draw Plug-Ins**

**FMECA Output**

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Johnson Space Center

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#### SysML Models

- **Operational State**
  - **Corrrotive Action**
  - **Failed State**

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#### Failure Modes and Effects Criticality Analysis

<table>
<thead>
<tr>
<th>Project Name: Fan in the Can SysML Model</th>
<th></th>
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<table>
<thead>
<tr>
<th>System</th>
<th>Subsystem</th>
<th>LRU/Assembly Type</th>
<th>LRU/Assembly Name</th>
<th>Item Function</th>
<th>Potential Failure Mode</th>
<th>Immediate Failure Effect</th>
<th>End Effect</th>
<th>Number of Independent Causes</th>
<th>Other Independent Causes</th>
<th>CRIT LEVEL</th>
<th>SEV</th>
<th>Potential Causes</th>
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<tbody>
<tr>
<td>FannCan</td>
<td>ECLSS</td>
<td>CCAA</td>
<td>CCAA1</td>
<td>CCAA1 Circulates Air</td>
<td>Failed Off</td>
<td>Loss of CCAA1 air Circulation</td>
<td>Loss of CCAA1 air Circulation</td>
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<td>Internal Mal</td>
<td>1</td>
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<td>Internal Mal</td>
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<td>MBSU1</td>
<td>MBSU1_distribute</td>
<td>Failed Off</td>
<td>Loss of MBSU1output_power</td>
<td>Loss of CCAA1 air Circulation</td>
<td>2</td>
<td>MBSU2 Failed Off</td>
<td>1</td>
<td>2</td>
<td>insert internal Mal</td>
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<td>MBSU1</td>
<td>MBSU1_distribute</td>
<td>Failed On</td>
<td>Loss of ability to manage MBSU1 loads</td>
<td>1</td>
<td>1</td>
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Example - CDS System Fault Tree

Courtesy Lui Wang
Johnson Space Center
FY16 Planned Collaboration – UMD Center for Advanced Life Cycle Engineering (CALCE)

Simulation Assisted Reliability Assessment (SARA®) Software

- GSFC has access to CALCE SARA® software to perform in depth parts reliability analysis
- A system model that links to SARA® could produce more accurate reliability analyses
- MBSE provides a framework to support this activity
Objectives Based Assurance

R&M Objectives Structure – Top-Level

Top Objective: system performs as required over the lifecycle to satisfy mission objectives

Strategy: prevent faults and failures, provide mitigation capabilities as needed to maintain an acceptable level of functionality considering safety, performance, and sustainability objectives

Context: Expectations derived from crew safety, MMOD concerns, facility safety, public safety, mission obj., sustainment, ... considerations and associated risk tolerance

Context: System/function description and requirements, including design information and interfaces

Context: Reference mission + before/after

Context: Range of nominal / off-nominal usage and conditions/ environments

Objective: system conforms to design intent and performs as planned (1)

Objective: system remains functional for intended lifetime, environment, operating conditions and usage (2)

Objective: system is tolerant to faults, failures and other anomalous internal and external events (3)

Objective: system is designed to have an acceptable level of availability and maintenance demands (4)
Laying the Foundation

- Logically decompose top-level R&M objective
  - Use elements of the Goal Structuring Notation
  - Structure shows why strategies are to be applied

- Structure forms basis for a proposed R&M standard
  - Specifies the technical considerations to be addressed by projects
  - Forms basis for evaluation of plans, design, and assurance products
MBSE provides an unprecedented opportunity to integrate SMA and Engineering Analysis concurrently as part of a common modeling framework.

MBMA, part of the MBSE environment, facilitates and enhances SMA’s analytical and risk assessment capabilities.

MBSE and MBMA fully supports GSFC’s Risk Based SMA Approach and the Agency’s R&M Objectives Structure and as part of a larger Safety/Assurance Case.