MODELING APPROACH FOR OPERATIONS REVITALIZATION

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Multi-Mission Ground Software & Services Program
JPL, Caltech
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And Stakeholders too numerous to list...
Outline

- Context for Mission Operations Systems
- Approaches & Methods
  - Architectural
  - Model-based
- Insights & Results
Context

• AMMOS
  • Advanced Multi-Mission Operations System
  • Product line: Adaptable tools and services
  • Cost advantage to Missions & NASA
  • “Why re-invent the wheel?”

• Ops Revitalization Initiative
  • Enhance, extend multi-mission Ops and associated savings

• MOS 2.0
  • The Next-Generation MOS
Context

• Pressure to lower costs
• Missions want more
  • Capability (they’re more complex)
  • Flexibility (unique needs to meet)
• AMMOS is modernizing
  • Architecture is 40+ years old
  • Has evolved organically
  • Multiple, localized improvement efforts, no “magic bullet”
An Architectural Approach

• Principled
• Stakeholder-focused
• Components, connections, constraints
• Separation of concerns
• Identification of fundamental patterns
• Model-Based Methodology
  • Didn’t start with MBSE
**Architectural Principles**

- Intended to be pervasive invariants
- Inform design and implementation
- Not requirements (not strictly verifiable)

<table>
<thead>
<tr>
<th>– Primacy of Principles</th>
<th>– Technology Independence</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Close The Loop</td>
<td>– Universality of Information Security</td>
</tr>
<tr>
<td>– Customer Focus</td>
<td>– Use of Common Services</td>
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<tr>
<td>– Info Accessibility</td>
<td>– Authoritative Sources of Information</td>
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<td>– Interoperability (open standards)</td>
<td>– Develop With What You Fly With</td>
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<td>– Learn from Experience</td>
<td></td>
</tr>
</tbody>
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Method

• Elicit Input from Stakeholders and SMEs
  • Variety of expertise and experience
• Discover Patterns from input
  • Discover similarity out of varying perspectives
• Identify Formal Concepts
  • Create Detailed Model of Pattern
• Incorporate into Framework
  • Integrate the concepts into whole framework
• Implement Multi-Mission System
  • Utilize framework to build multi-mission system
• Implement Mission-specific adaptation
  • Deploy multi-mission System for a Mission
Stakeholder Engagement

- Directly engaged with domain experts via meetings, 1-1 interactions, talks, etc.
- Major Concerns include:
  - Control and estimate of State
    - Of spacecraft and instruments
  - Lifecycle support by MOS for Mission
    - Support for formulation-phase mission trades
    - Availability during FSW development, system I&T
  - Adaptation (or Development) of the MOS
    - Ease in formulating/implementing (maximizing reuse)
Architectural Concepts Identified

- Timelines
- Control System
- Capabilities offered According to Agreements (Services)
- Queue System (Poisson Process)
- Standardized Design Specs

**Key Point**
- Each has a value proposition that supports the overall business case
EXAMPLES

Timelines
Control System Services
\{ Synthesis \}
Elicit: File-based Information
Elicit: Duplication of Information

- Current MOS products have duplicate information

- ...and when information is not directly available it is made available via custom scripts
Discovery: Timelines

- Planned Activity Timelines
- Planned Command Timelines
- Predicted State Timelines
- Telemetry Timelines
- Inferred State Timelines

Activity

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Elicit: MOS does Uplink & Downlink
Discovery: MOS Controls the Mission

Plan Mission Operations

Analysis

Plan

Approved Plan

Execute Planned Mission Operations

Analyze Observations and Planned Mission Operations

Observations
Synthesis: Control Oriented Timelines
Timeline-Based Control

Plan

Timelines
- Planned
- Commanded
- Predicted
- Observed
- Estimated
- Reconciled
- ...

Execute

Analyze
Control Interactions

MOS 2.0 has several key interfaces with other systems. For a given deployment, MOS 2.0 receives requests for work and products from the Project and Project Science. MOS 2.0 is composed of Services. These services perform the work necessary to command and control mission resources in pursuit of Mission and Science Objectives.
Controlling Interface

MOS

MOS-Ground Communications Network Interface

MOS-Ground Station Controller Interface

Monitor Data -0158
Actual Measurement DSS System Timeline

DKF
Actual Command DSS System Timeline

Ground Station Controlled Interface

Ground-MOS Interface

DSN
Directing Interface

Mission Engineering Service

DIRECTS

Science Instruments Engineering Service

This is the Director Port

This is the Directed Port

Mult-mission Ground Software & Services
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AMMOS Lifecycles

Project and Mission Deployment Lifecycle

- Project Start - Pre-launch Development
- Mission Adaptation Operations Concept
- Mission Adaptation
- Process Concept
- Mission Operations
- Deployed Multi Mission Operations

Life of Multi-Mission Product

- Multi Mission Continous Product Development Operations
- Multi Mission Continuous Product Development
Adaptation Concept
Lessons & Best Practices

• Understand the problem first
• Know and keep working your value proposition(s)
  • Never quit advocating. Consider it part of your scope of work.
• Prototype, demo early and often
  • You must show value to your sponsors
• Build communities of practice
• Build stakeholder community
Lessons & Best Practices

- Find evolutionary paths from As-Is to To-Be
  - And know when you need to deprecate
- Leverage standards
  - Industry (SysML, UML, IEEE-1471…)
  - Your institution (e.g., JPL – Gate Transition Products)
- Think early about model organization & CM
  - It will evolve, but you need a plan
- Document and follow processes
  - We built a process for stakeholder engagement
- Be able to speak in stakeholder language
Summary

• MBSE has potential to generate efficiencies in all phases of Projects and throughout lifecycle of product lines
  • Major productivity gains are still low-hanging fruit.
• Rigor of modeling can yield clarity and new solutions to old problems
• Cultural issues are at least as important as the technical ones
Backup
Issues and Challenges for MBSE

- Culture – inertia and skepticism
- Need for advocacy and support
- Hard to scope & estimate work
- Methods, tools, standards evolve (fast)
- Infrastructure is needed
  - DocGen/DocWeb have been vital for OpsRev
  - MagicDraw servers, licenses
- Trained modelers
Use of modeling

• More rigorous capture of intent, specs.
  • SysML v. English

• Explicit, standard specifications
  • Vs. shared implicit (inconsistent) understanding by individuals

• Single authoritative source of design information
  • “Which version of the document is it? When was this updated last?”
Use of modeling

• Ability to automate
  • “Pushbutton” document publication
  • Leverage design patterns, automate modeling of common elements.

• Increased ability to manage complexity
  • Connections between model elements can be queried; are never forgotten

• Tighter coupling between design intent and implementation
  • e.g., Timelines specified in SysML automatically transformed to schema in a repository for use in software