

MODELING APPROACH FOR OPERATIONS REVITALIZATION

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Multi-Mission Ground Software & Services Program
JPL, Caltech
Presentation to the OMG SE DSIG
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Ops Revitalization Team

- **Current**

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- Elyse Fosse (318)
- Dave Noble (318)
- Carlos Carrion (318)
- Michelle McCullar (318)
- Marc Sarrel (318)
- Rob Smith (318)
- Seung Chung (313)
- Chris Delp (313)

- **Previous**

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- Steve Schaffer (317)
- Jennifer Mindock (343)
- Jeannette Illsley (314)
- Glen Havens (318)
- Carole Boyles (680)
- Ben Holden (intern)
- Ryan Wollaeger (intern)

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)

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

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

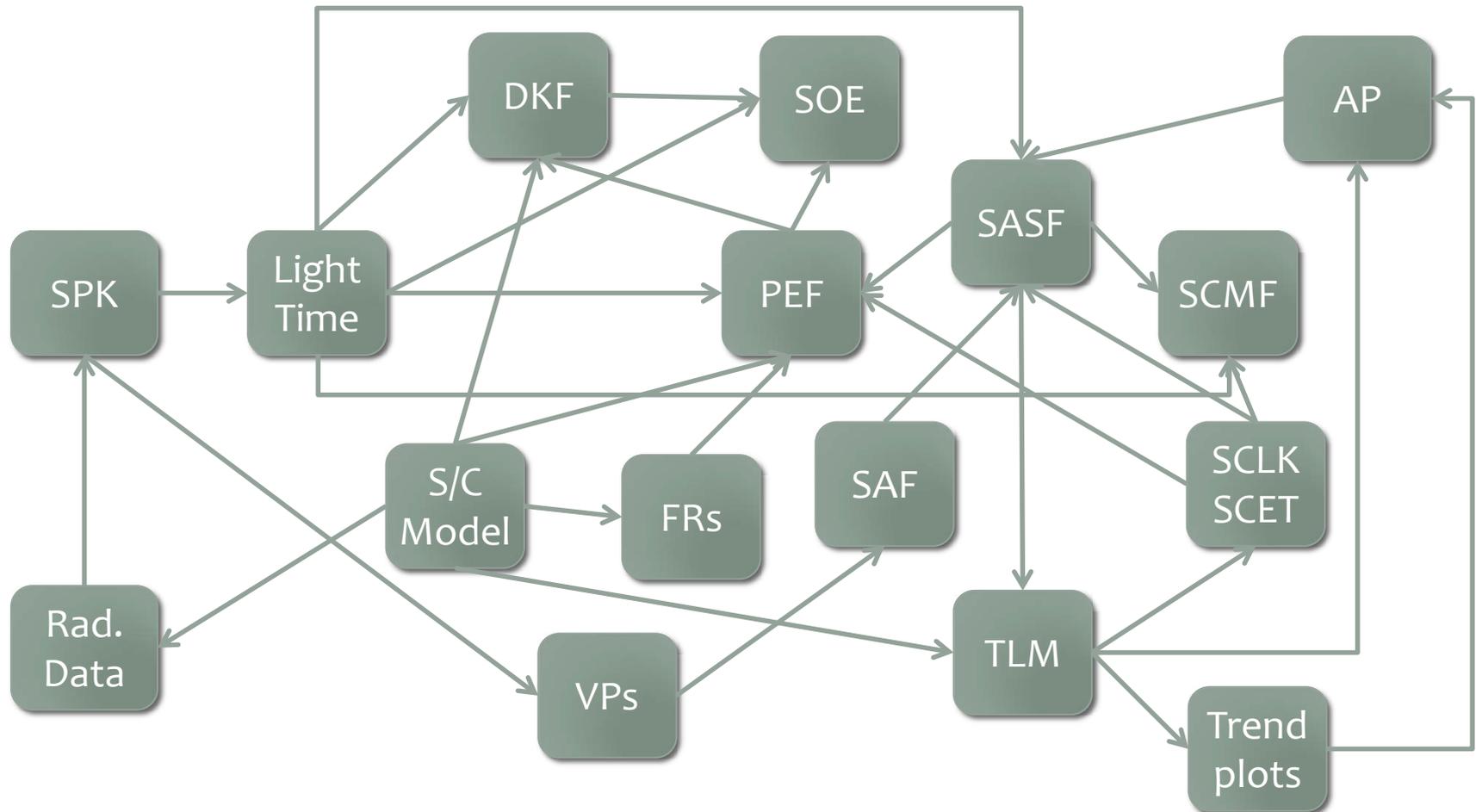
Services



Synthesis

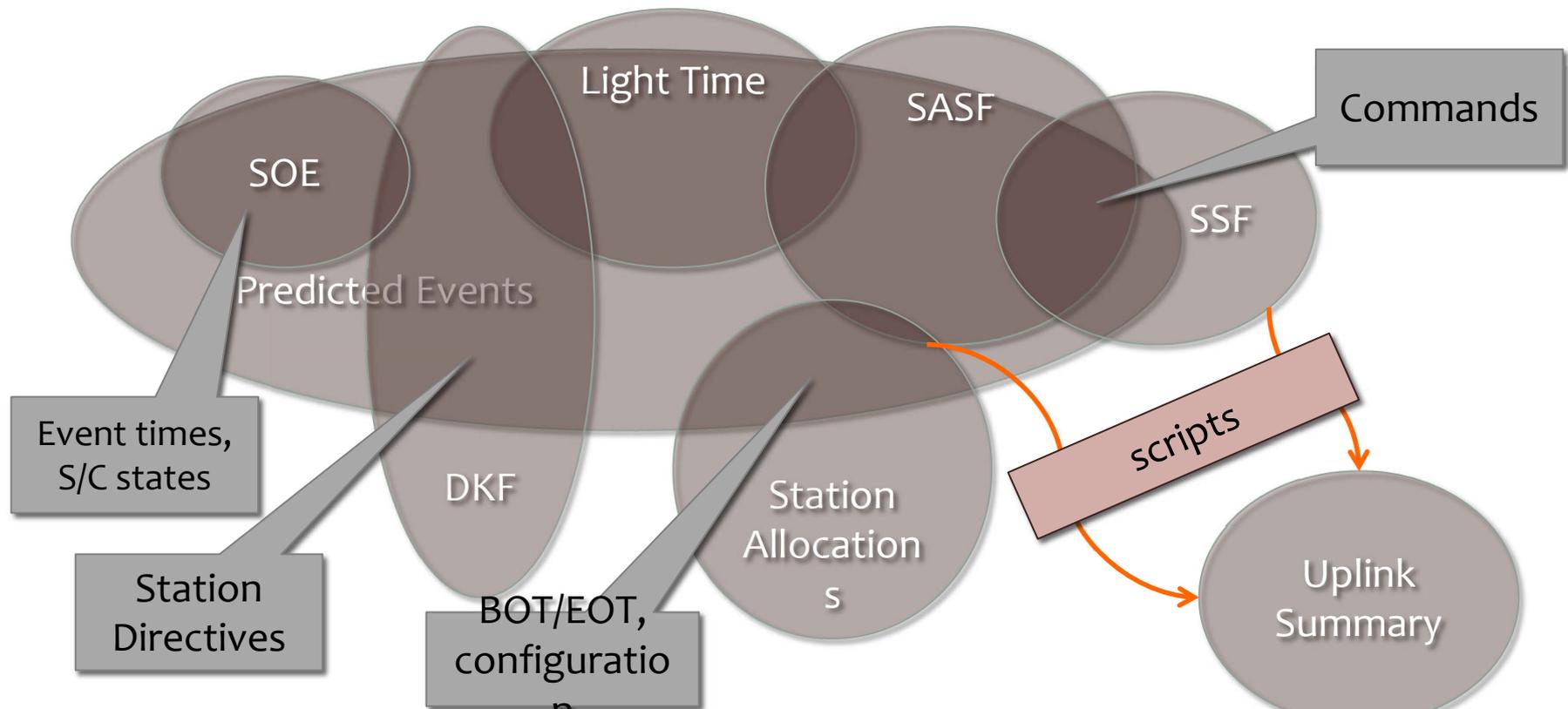


Elicit: File-based Information



Elicit: Duplication of Information

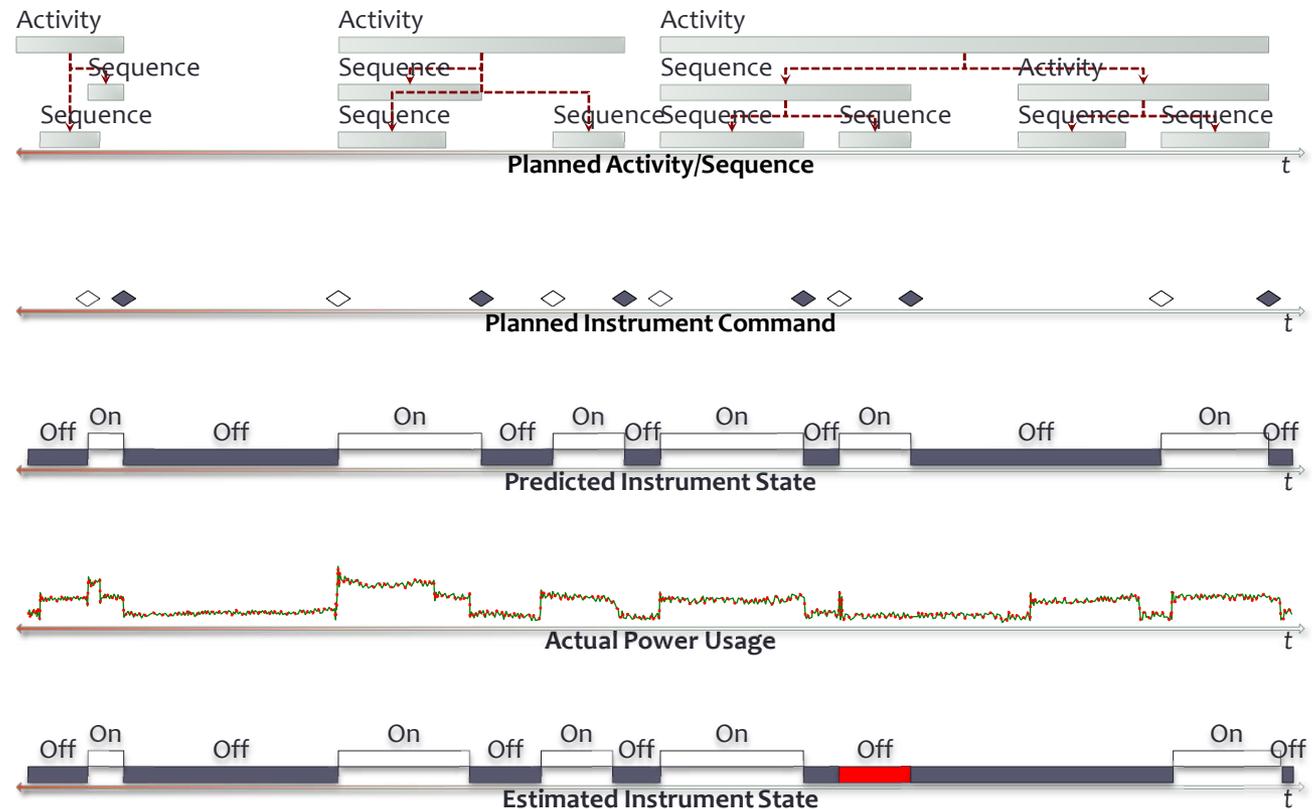
- Current MOS products have duplicate information



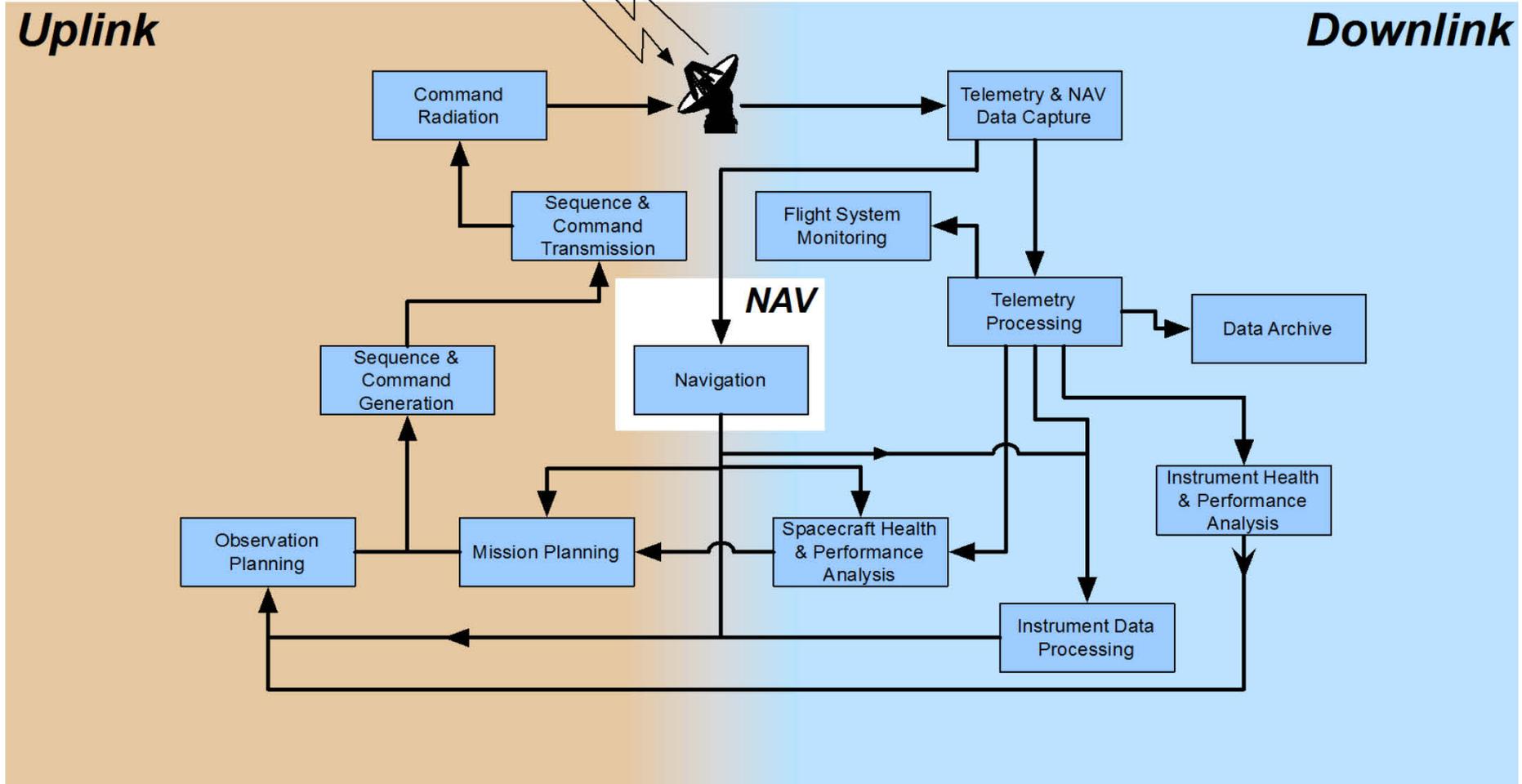
- ...and when information is not directly available it is made available via custom scripts

Discovery: Timelines

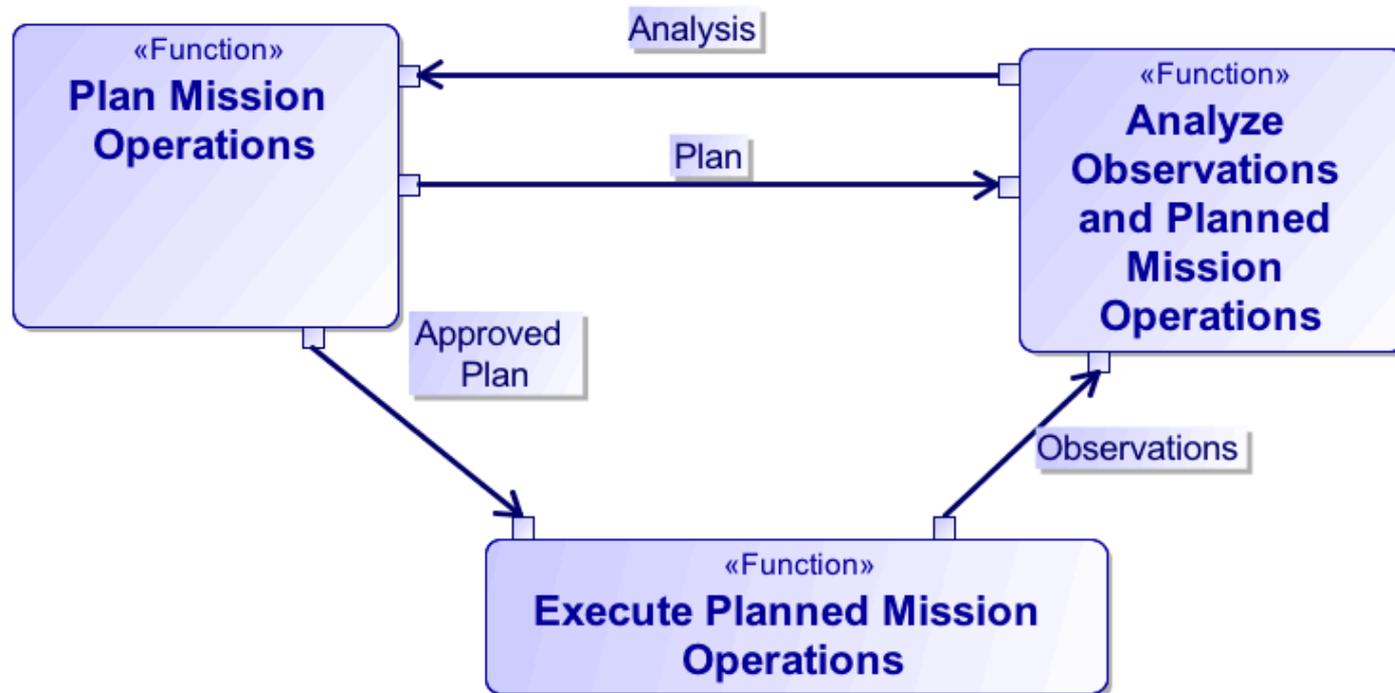
Planned Activity Timelines
Planned Command Timelines
Predicted State Timelines
Telemetry Timelines
Inferred State Timelines
...



Elicit: MOS does Uplink & Downlink



Discovery: MOS Controls the Mission



Synthesis: Control Oriented Timelines

Flight System Engineering

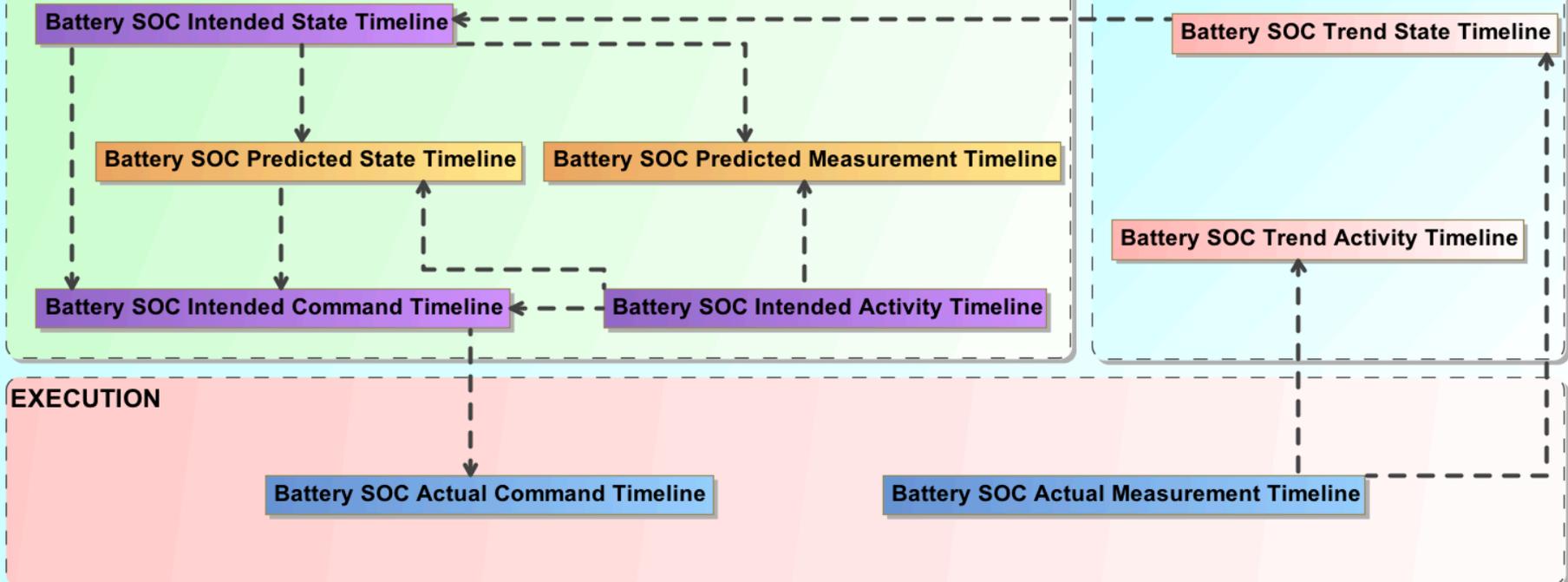
Power

ABSL Li-Ion Battery

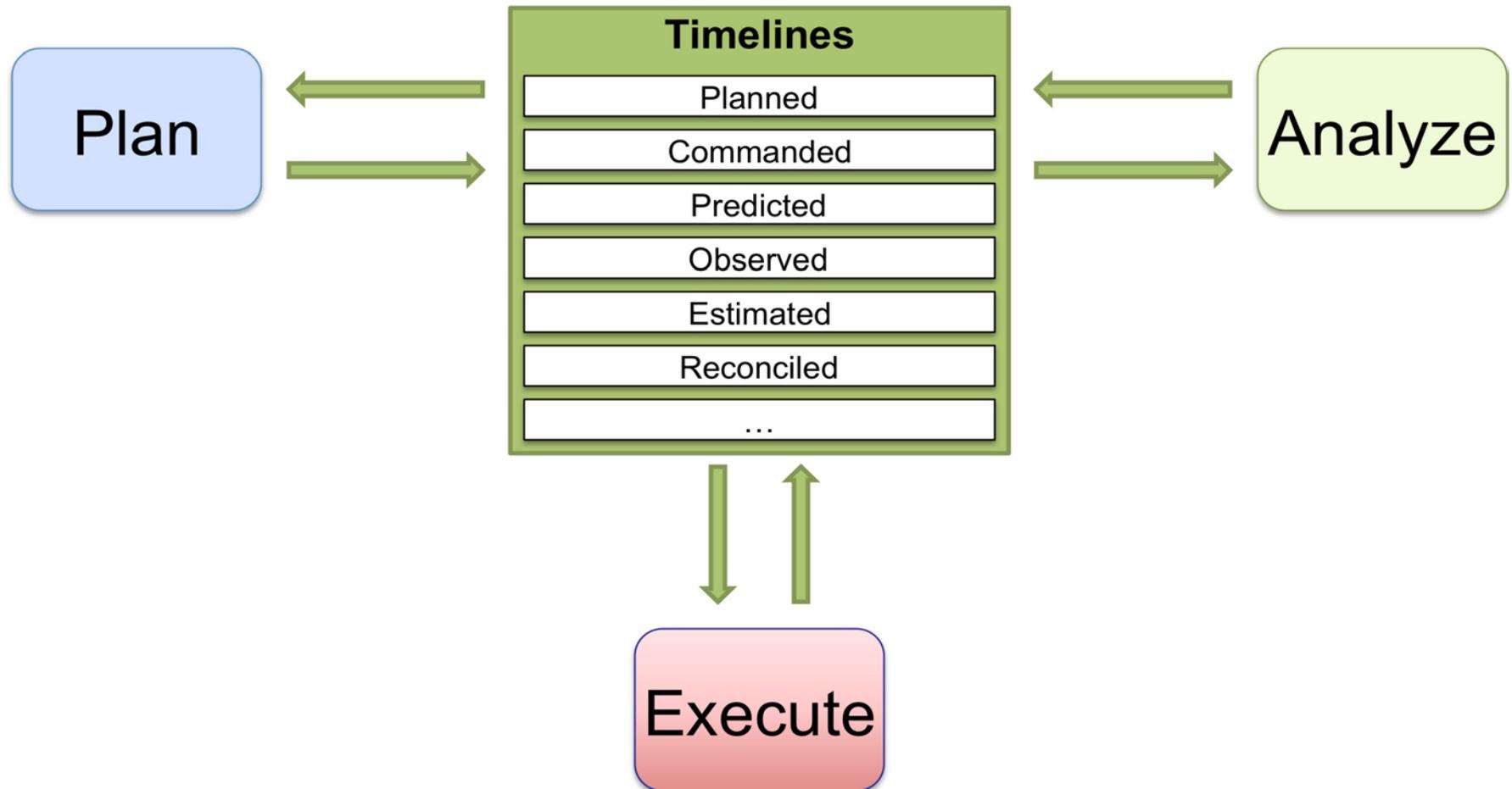
INTENTION PREDICTION ACTUAL TREND

PLANNING

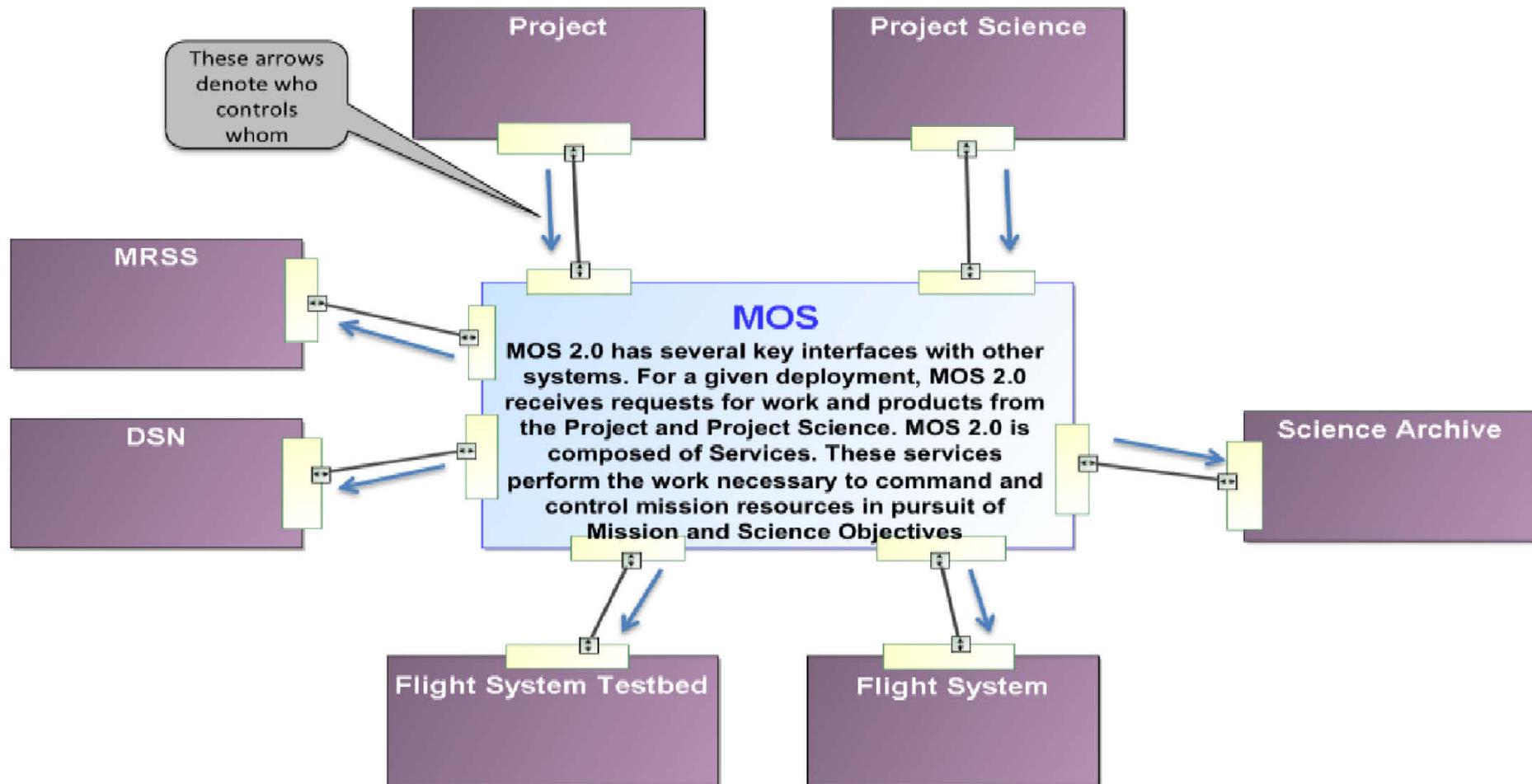
ANALYSIS



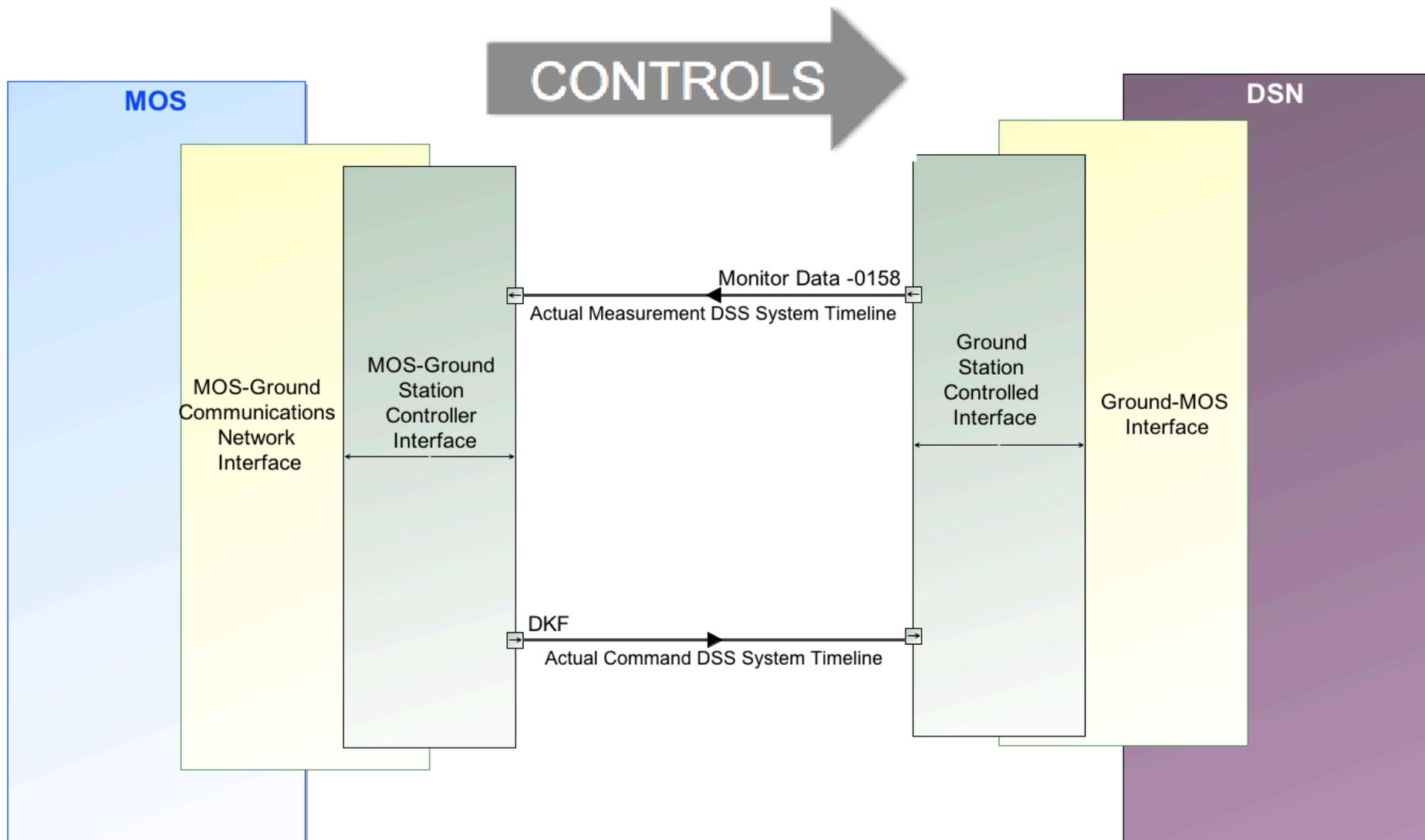
Timeline-Based Control



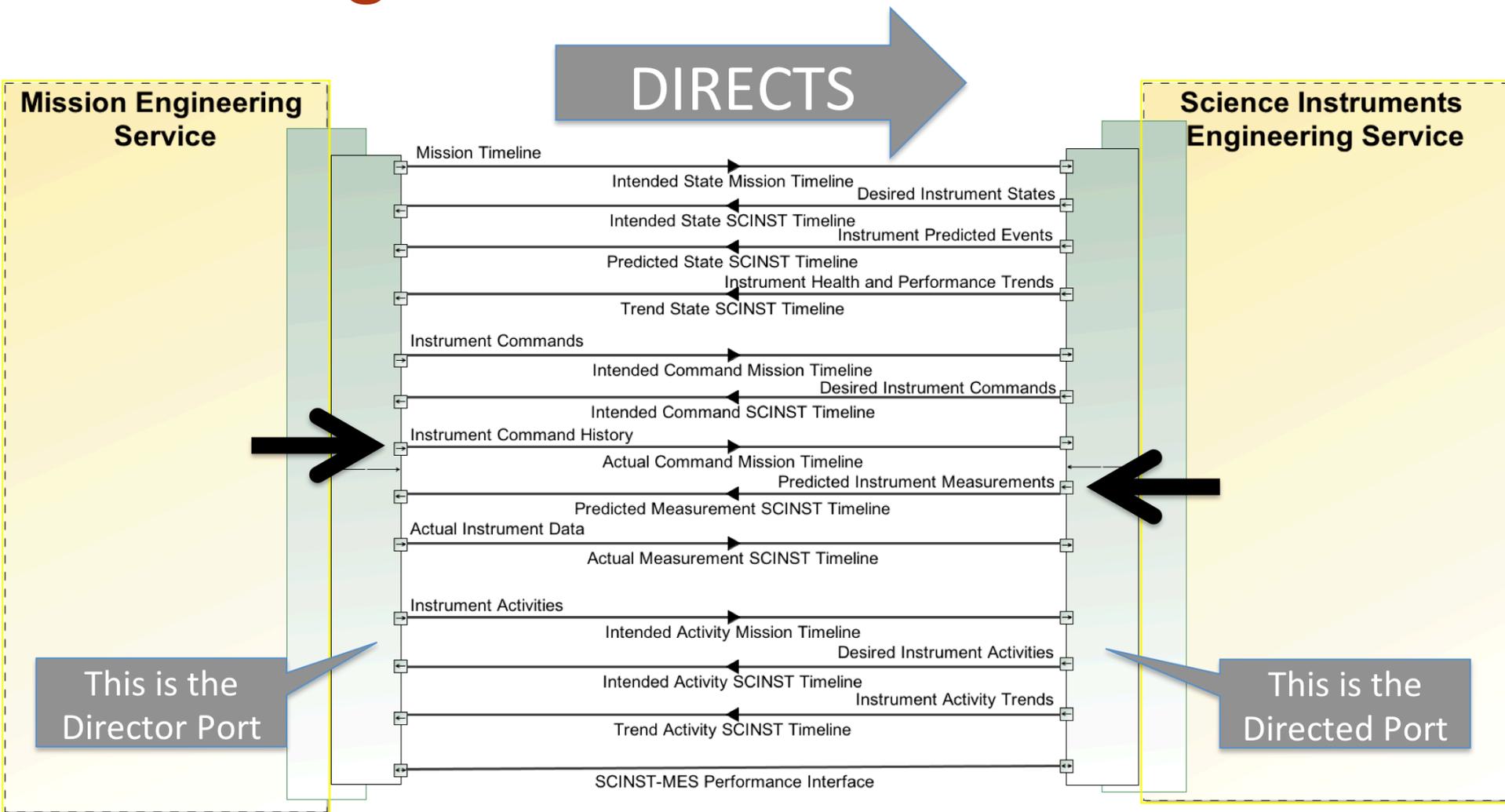
Control Interactions



Controlling Interface



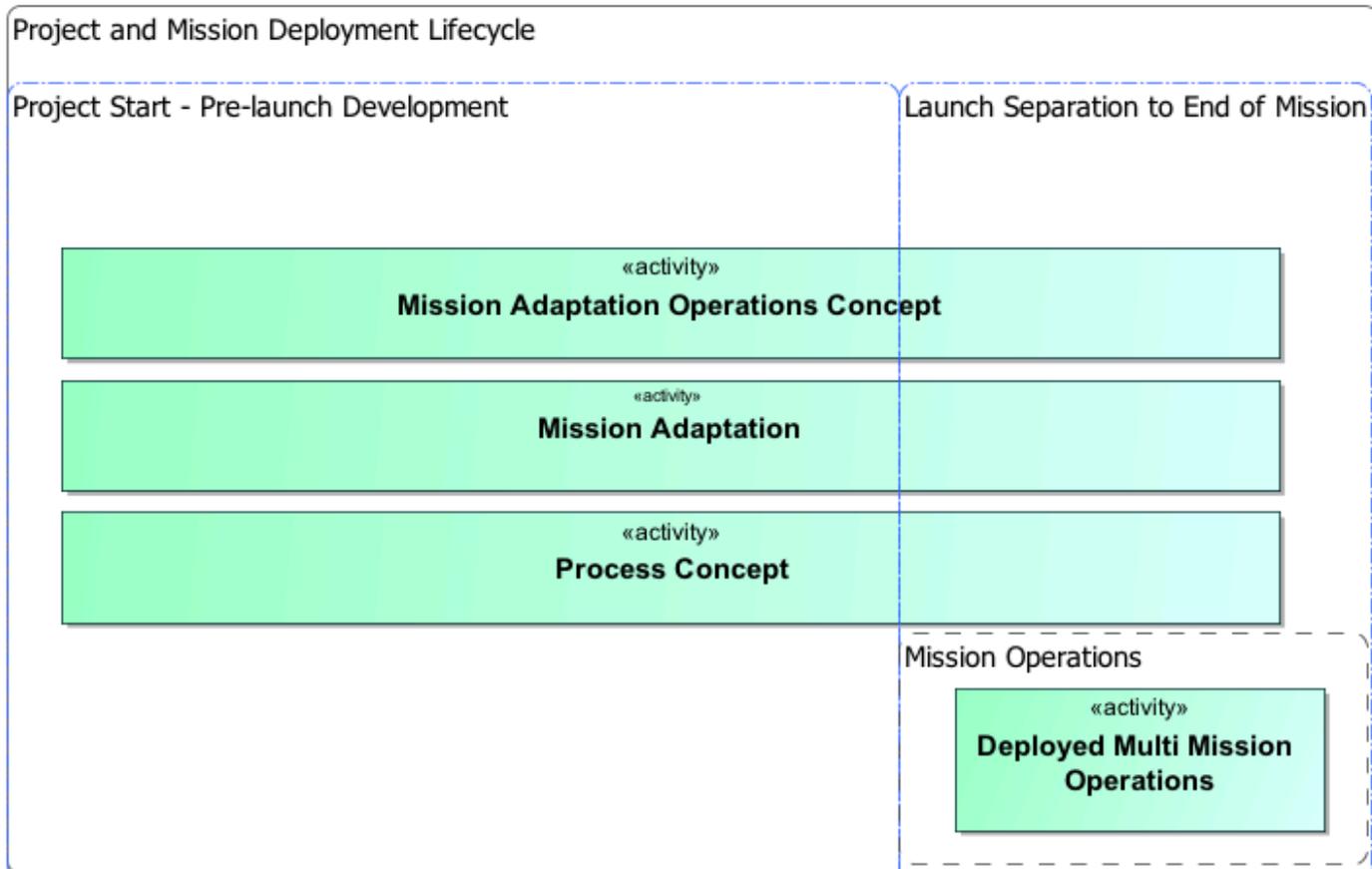
Directing Interface



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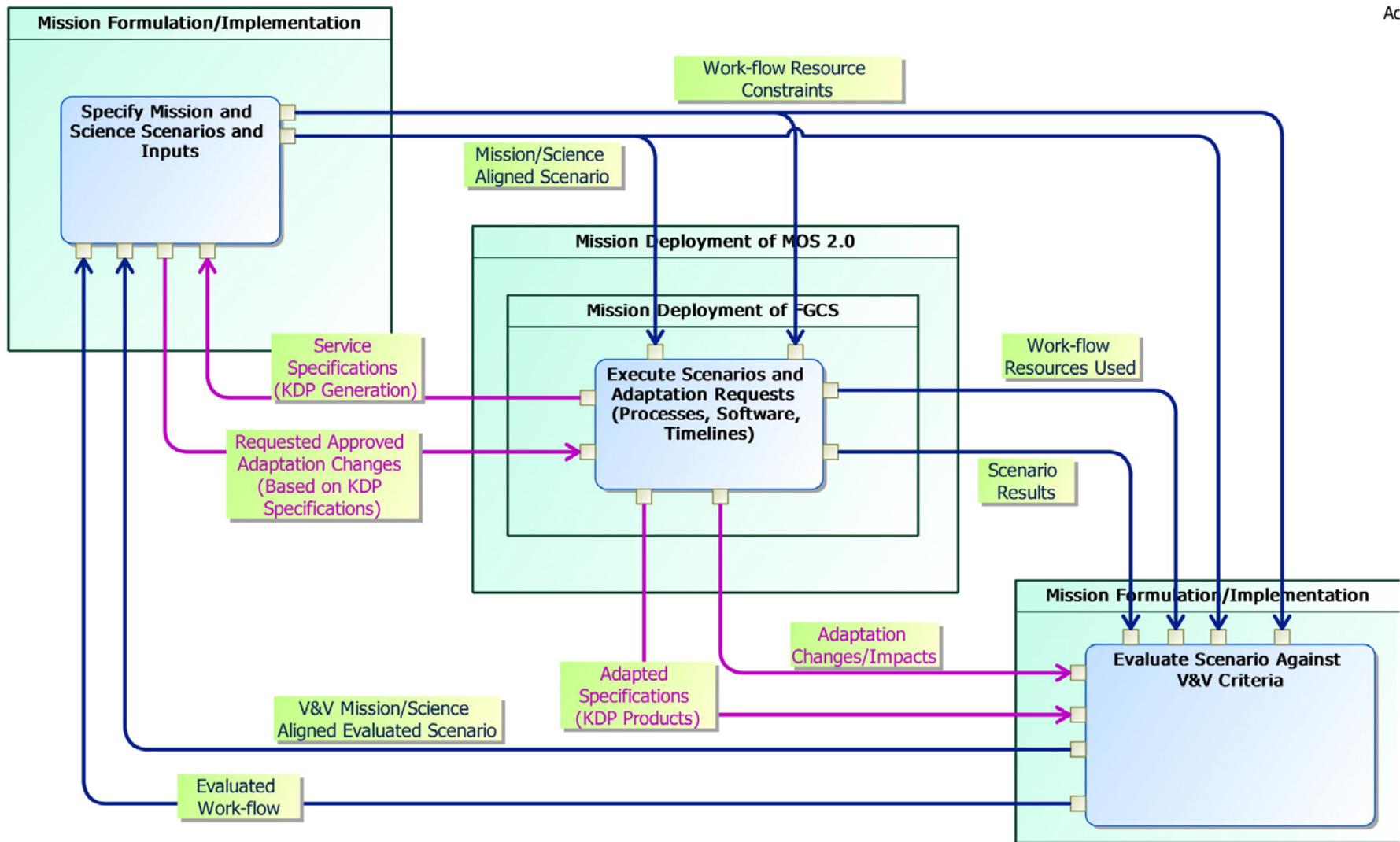
AMMOS Lifecycles



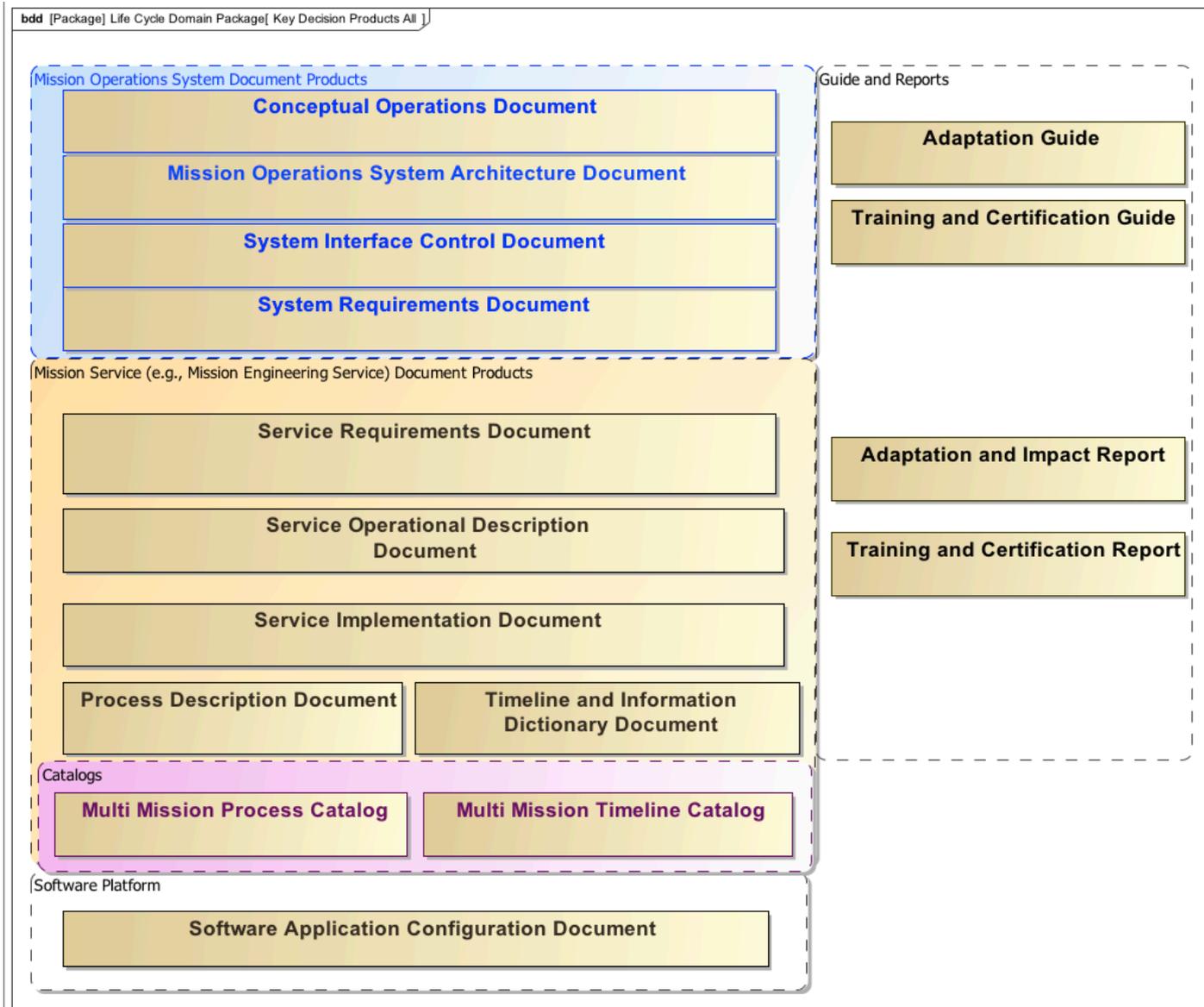
Life of Multi-Mission Product



Adaptation Concept



Documentation & Reports



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