# MBSE For A Product Line: MOS 2.0

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# Outline

- Context for Mission Operations Systems
- Approaches
  - Architectural
  - Model-based
- Examples
- Insights


# 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"

# Approach

- Establish scope, execute trades
  - Goals and Objectives, system lifecycle
  - Key trades:
    - architecture standards (DODAF, RASDS, IEEE-1471)
    - modeling tools (EA, MagicDraw)
- Use an architectural mindset
  - Components, connections, constraints
  - Separation of concerns
  - Identification of fundamental patterns
  - Stakeholder Engagement


# 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


# Architectural Concepts Identified

- Timelines
- Control System
- Process
- 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


# 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

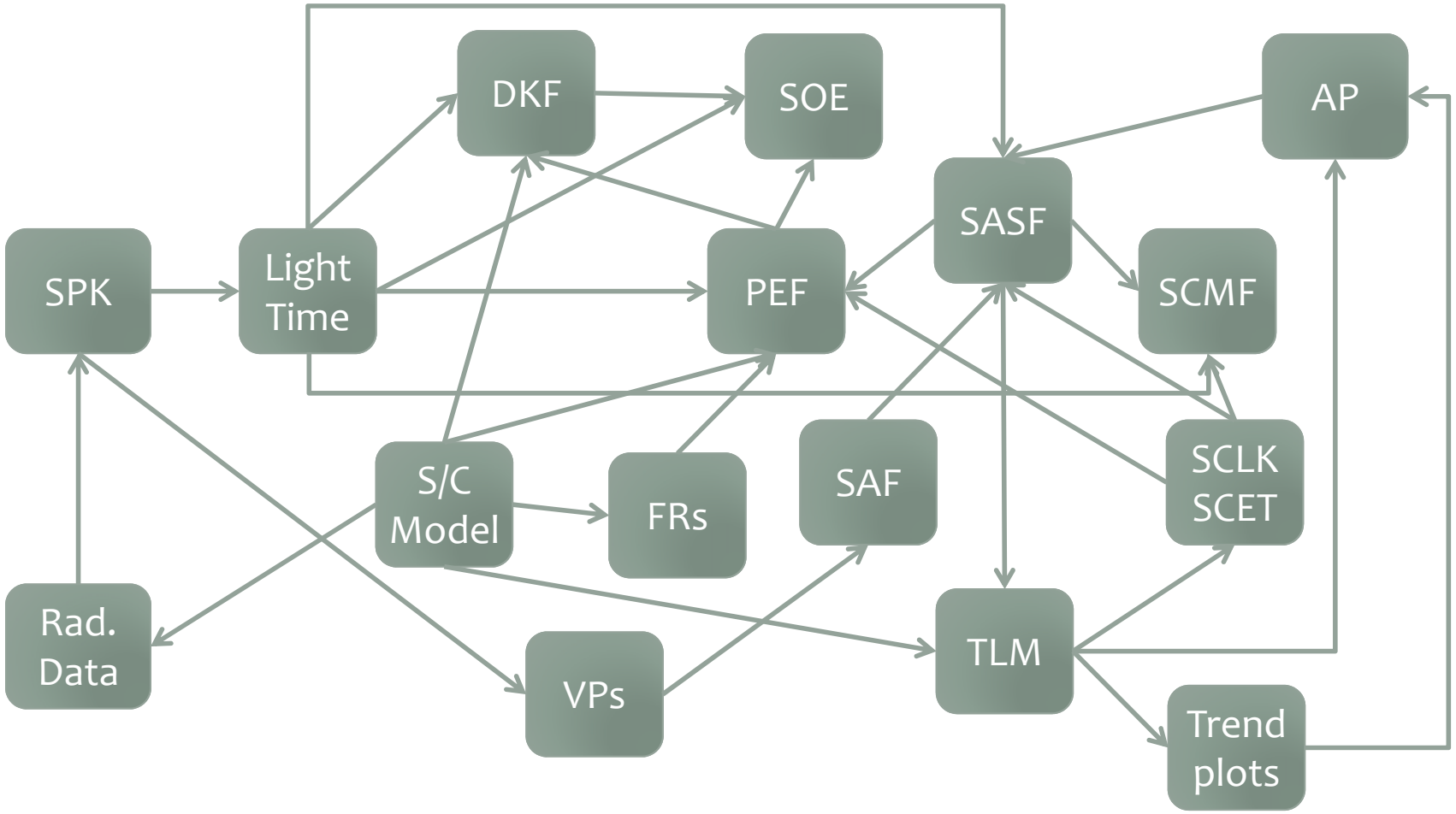
- Ability to automate
  - “Pushbutton” document publication
  - Leverage design patterns, automate modeling of common elements.
- Increased ability to manage complexity
  - Connections between model elements can be queried; are never forgotten
- Tighter coupling between design intent and implementation
  - e.g., Timelines specified in SysML automatically transformed to schema in a repository for use in software


# EXAMPLES

Timelines
Control System
Services

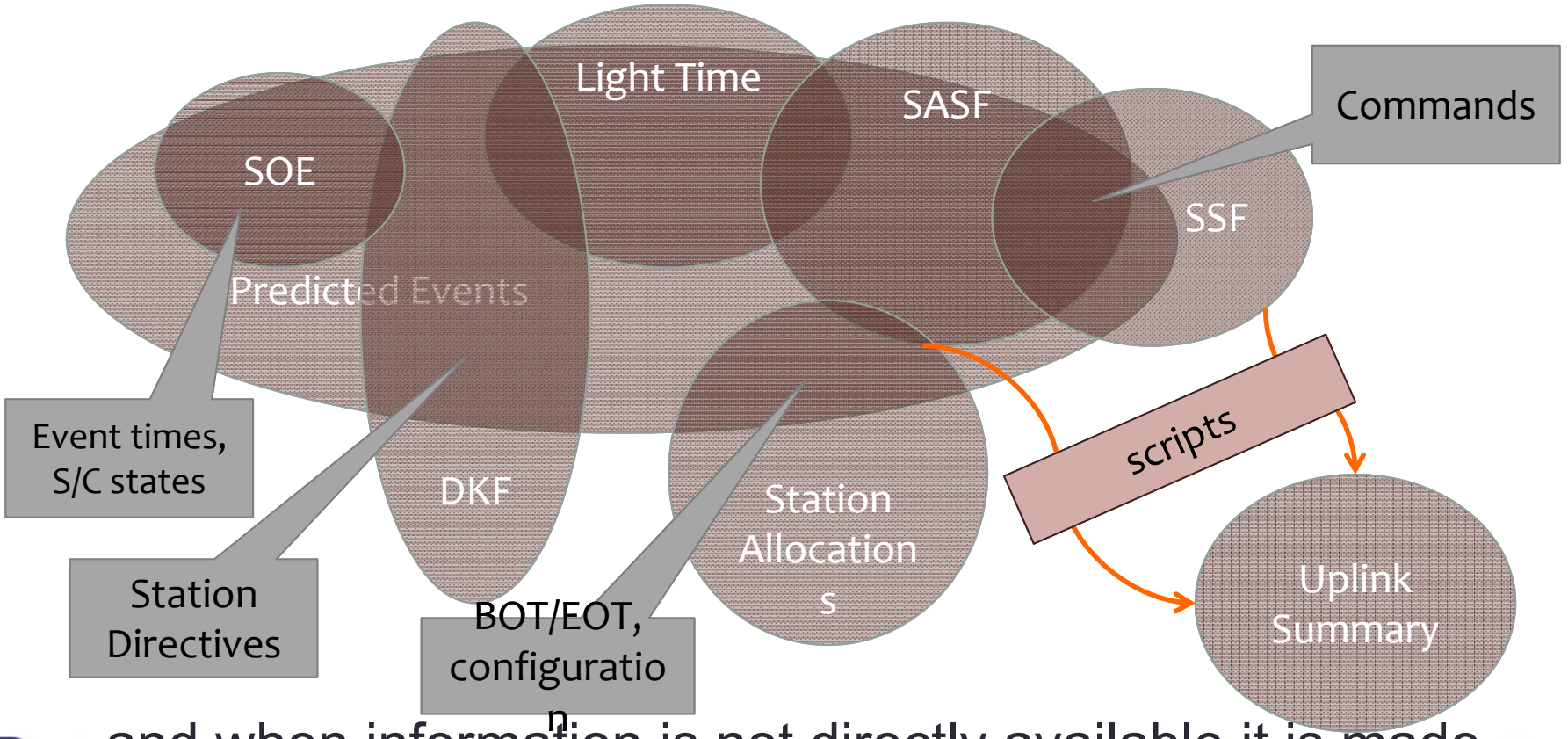
} Synthesis


# Elicit: File-based Information



# Elicit: Duplication of Information

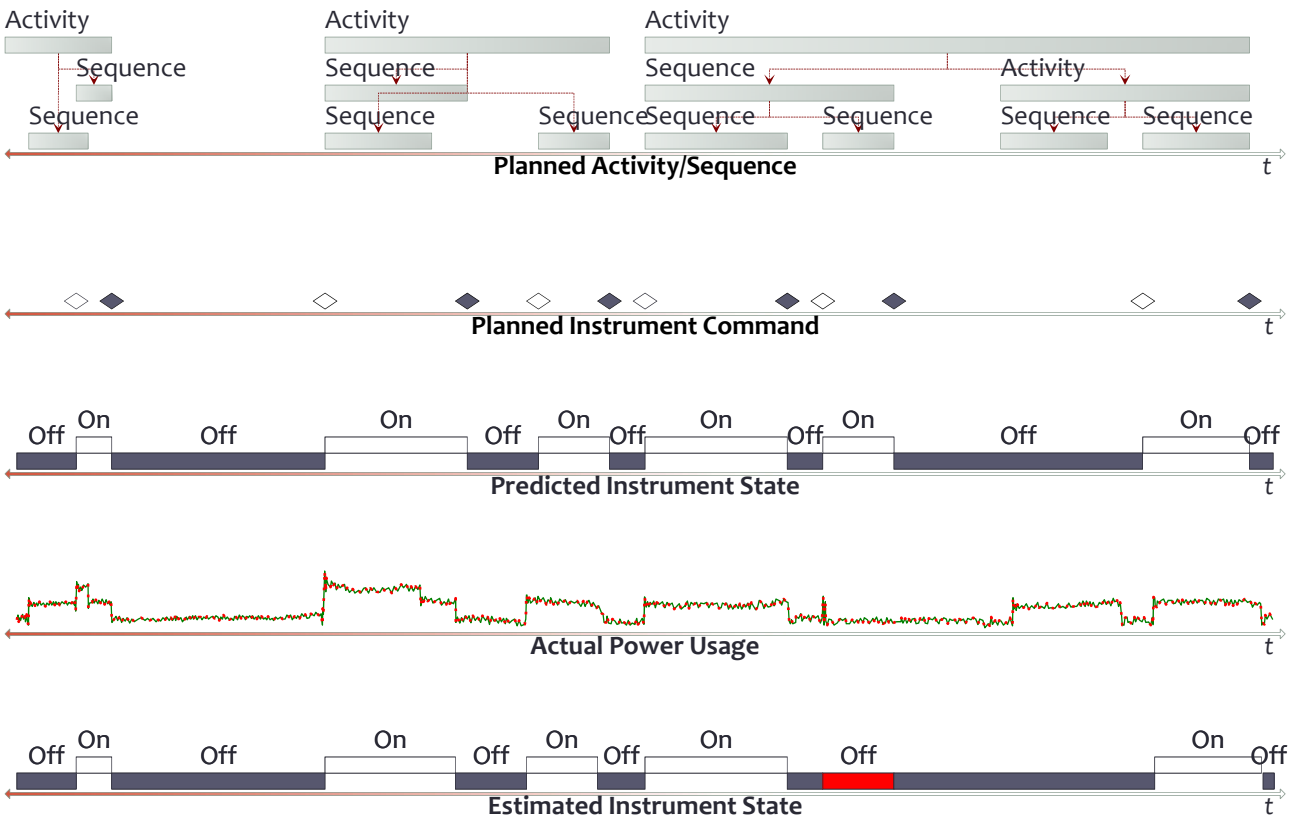
- Current MOS products have duplicate information



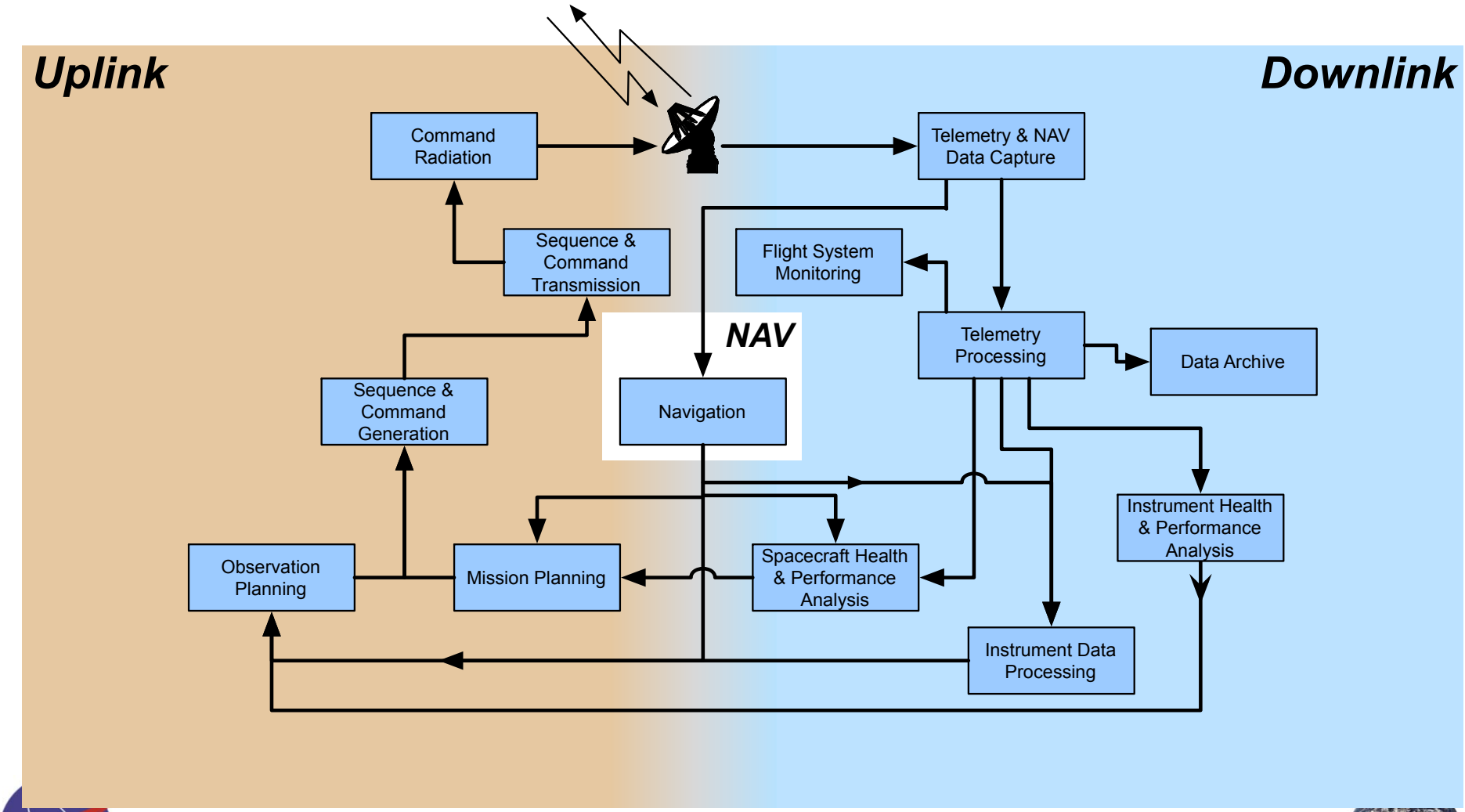

- …and when information is not directly available it is made available via custom scripts

# Discovery: Timelines

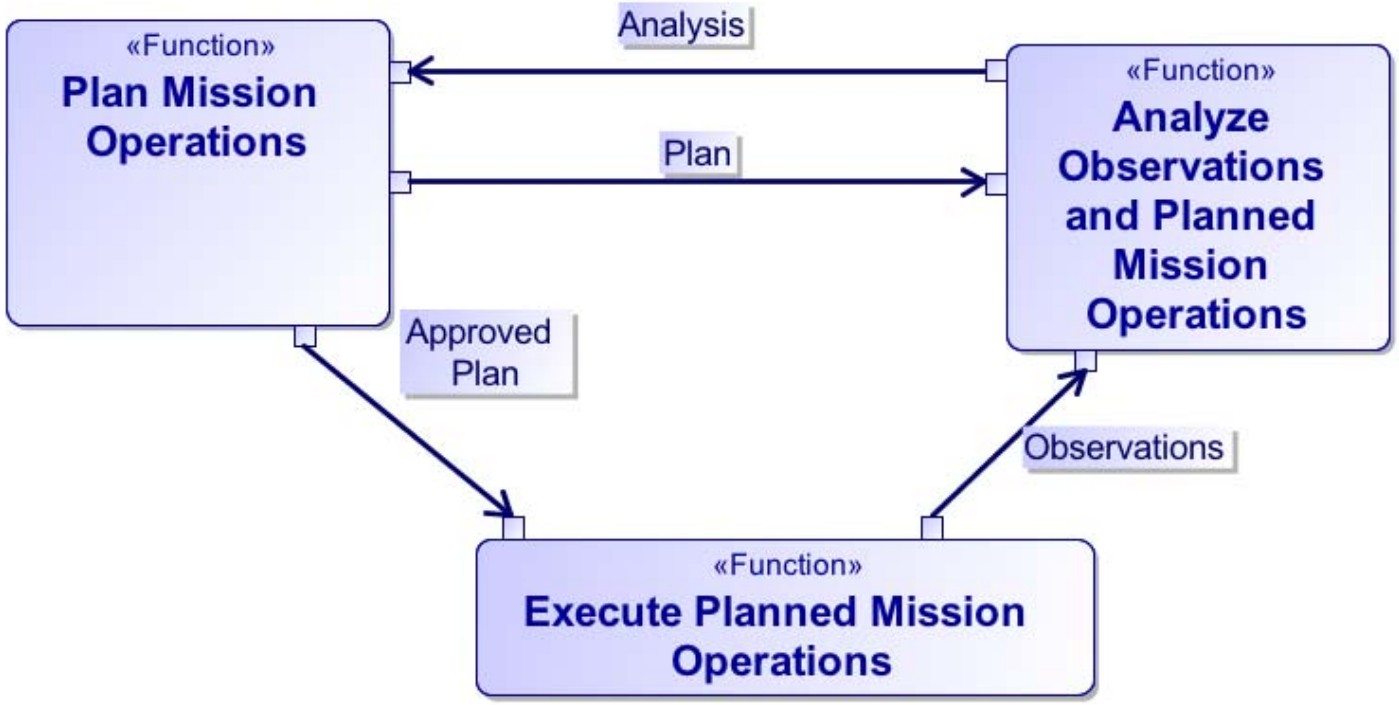
- Planned Activity Timelines
- Planned Command Timelines
- Predicted State Timelines
- Telemetry Timelines
- Inferred State Timelines
- …



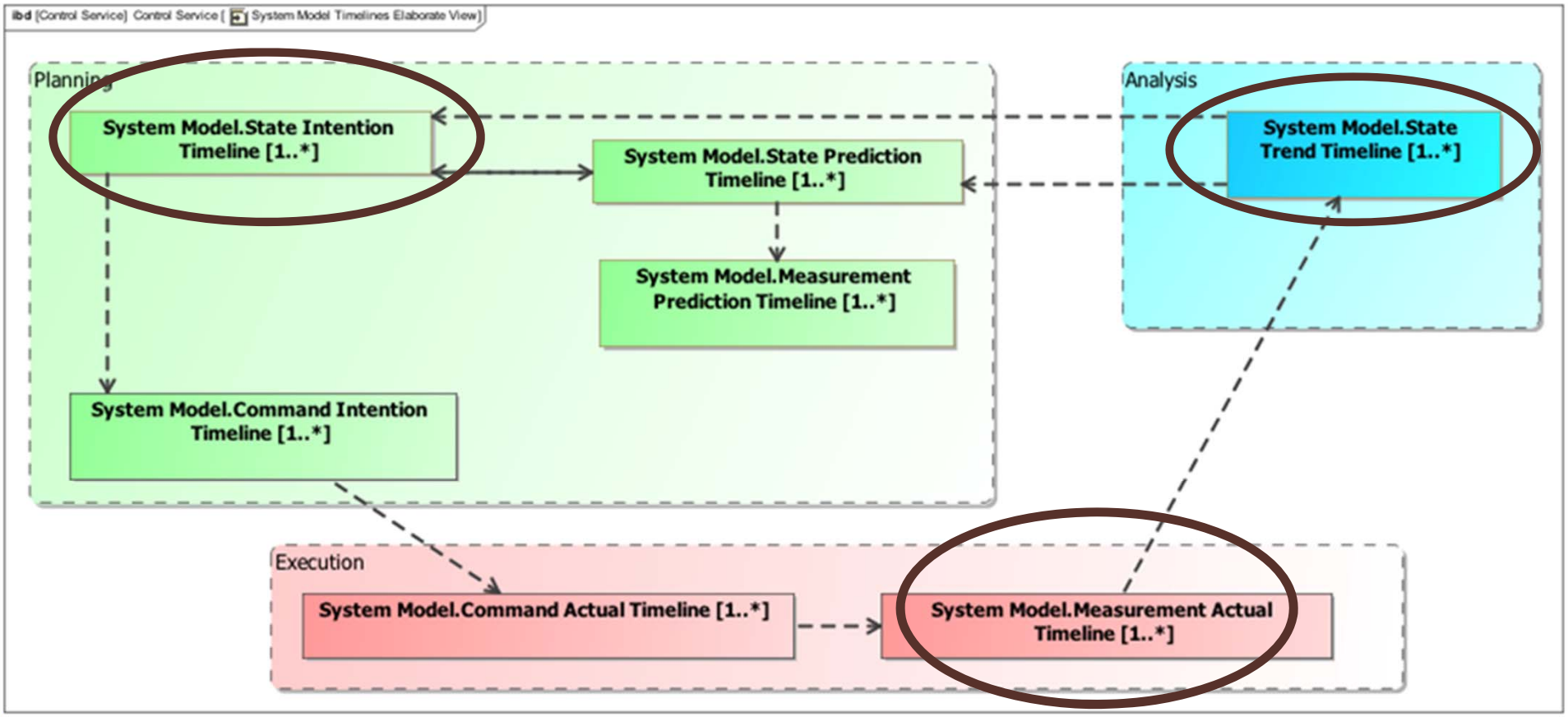
# Elicit: MOS does Uplink & Downlink



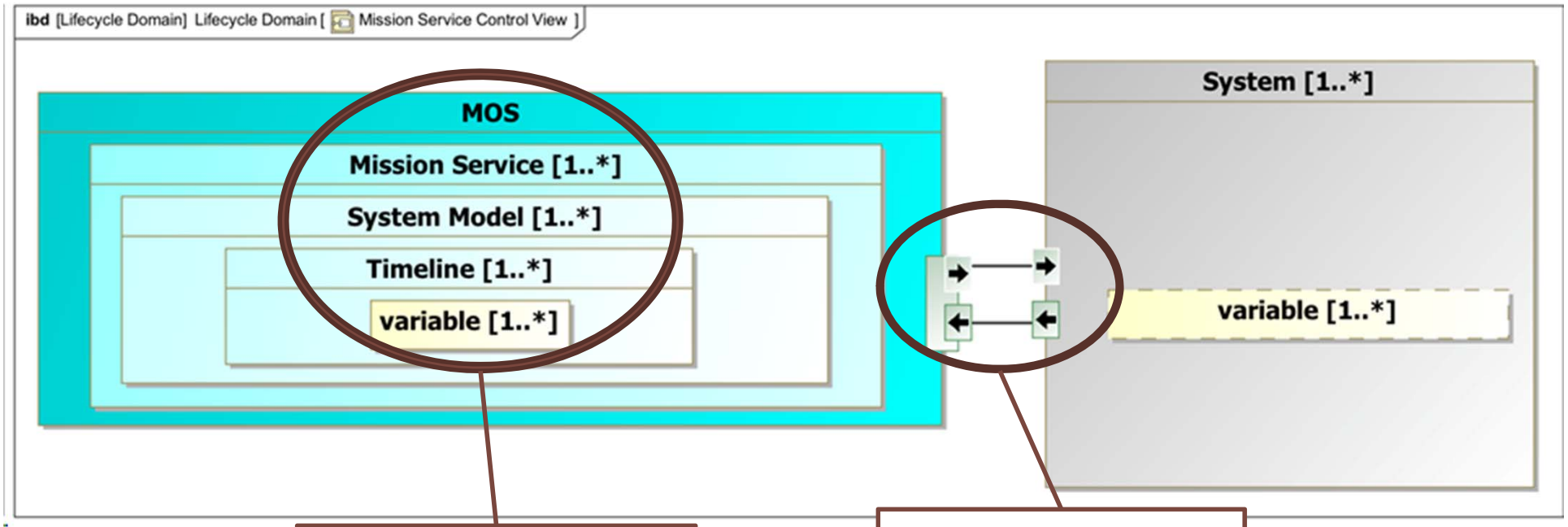
# Discovery: MOS Controls the Mission



# Synthesis: Control Oriented Timelines



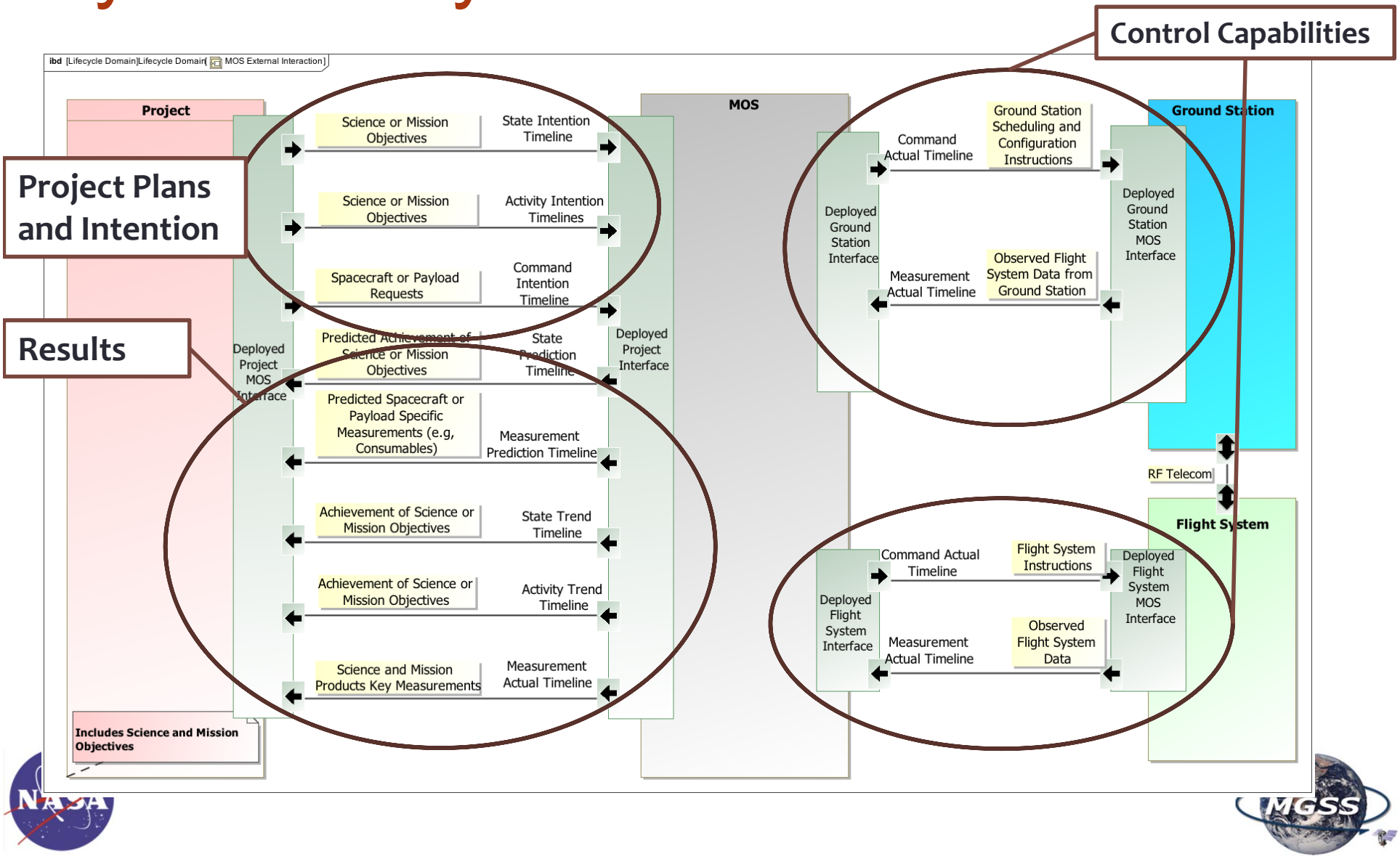
# Synthesis: Control as Service




Service Component + Control System + Timeline

Control System Interface Combined with Service Interface: Control Capabilities

# Synthesis: System Framework

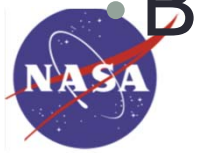


# Issues and Challenges for MBSE

- 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


# 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

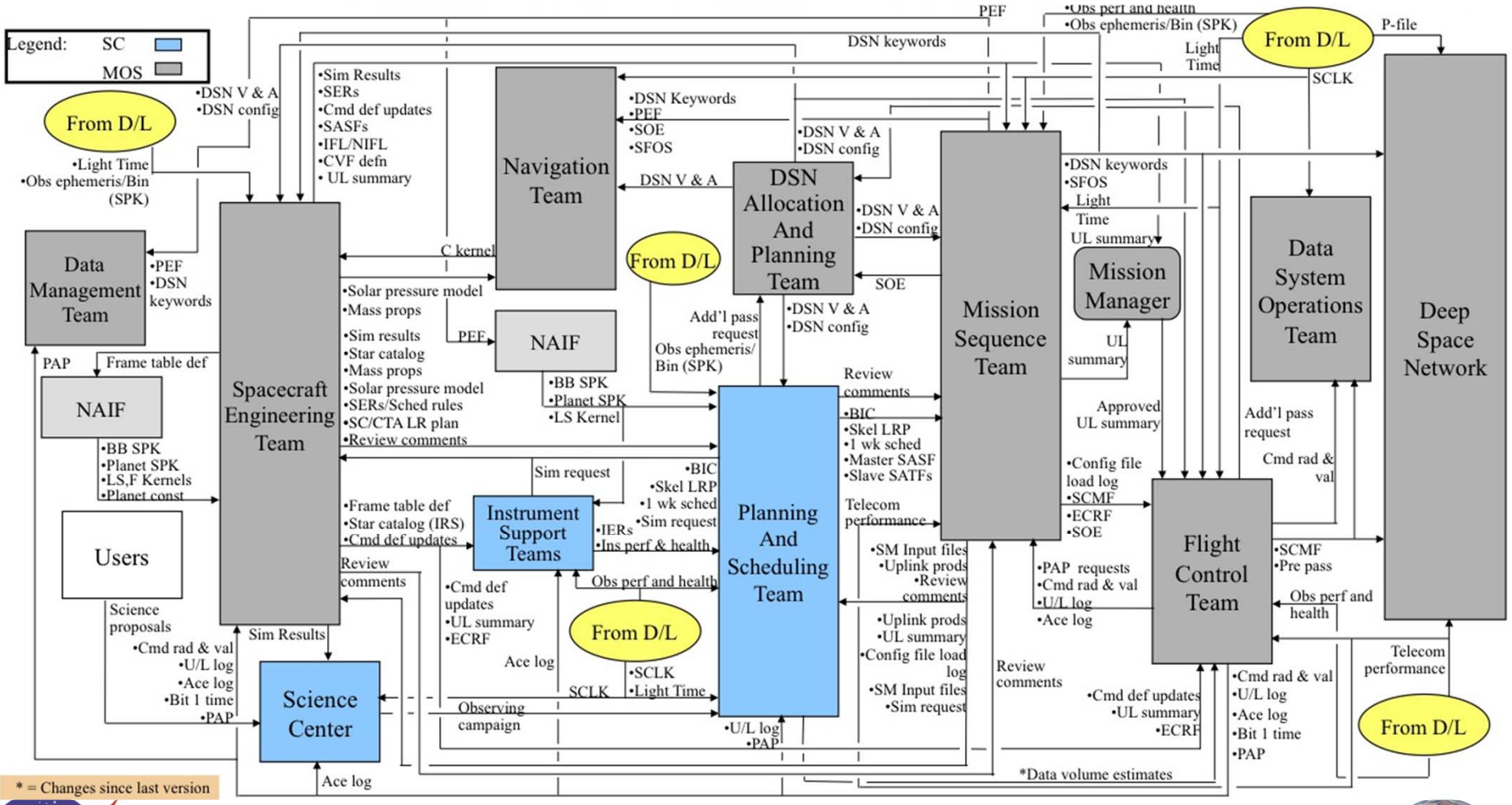
- MBSE has potential to generate efficiencies in all phases of Projects and throughout lifecycle of product lines
  - Major productivity gains are still low-hanging fruit.
- Rigor of modeling can yield clarity and new solutions to old problems
- Cultural issues are at least as important as the technical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


# Backup

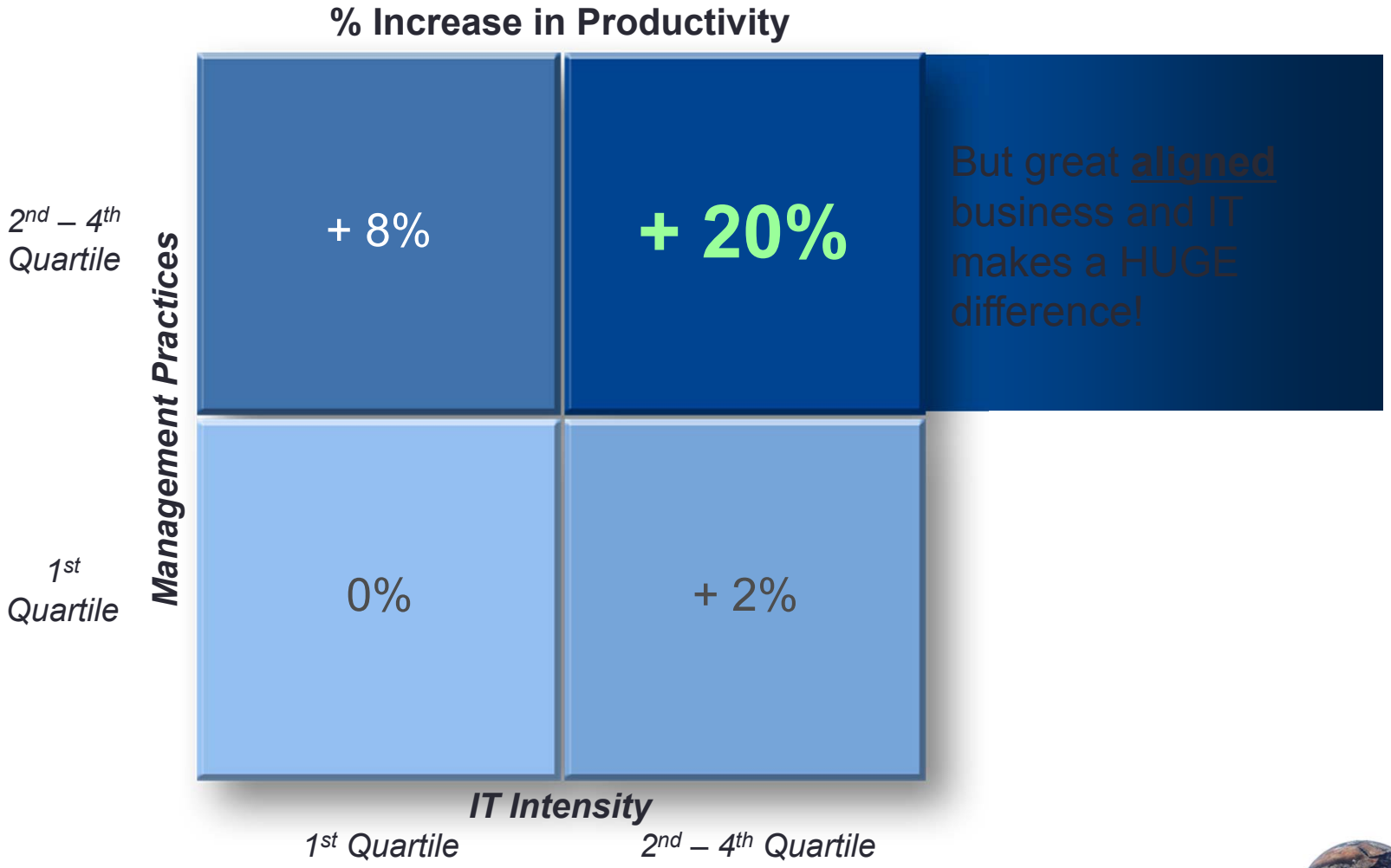

# Implications of MOS 2.0

- Goals-based operations
  - Support for onboard autonomy
- Develop with what you fly with
  - Rapid-prototyping approach to development
- Paths to automation
  - Facilitate “lights-out”operations
- Paths to autonomy
  - Ability to transfer function from ground to flight vehicle


# Opportunities to Improve

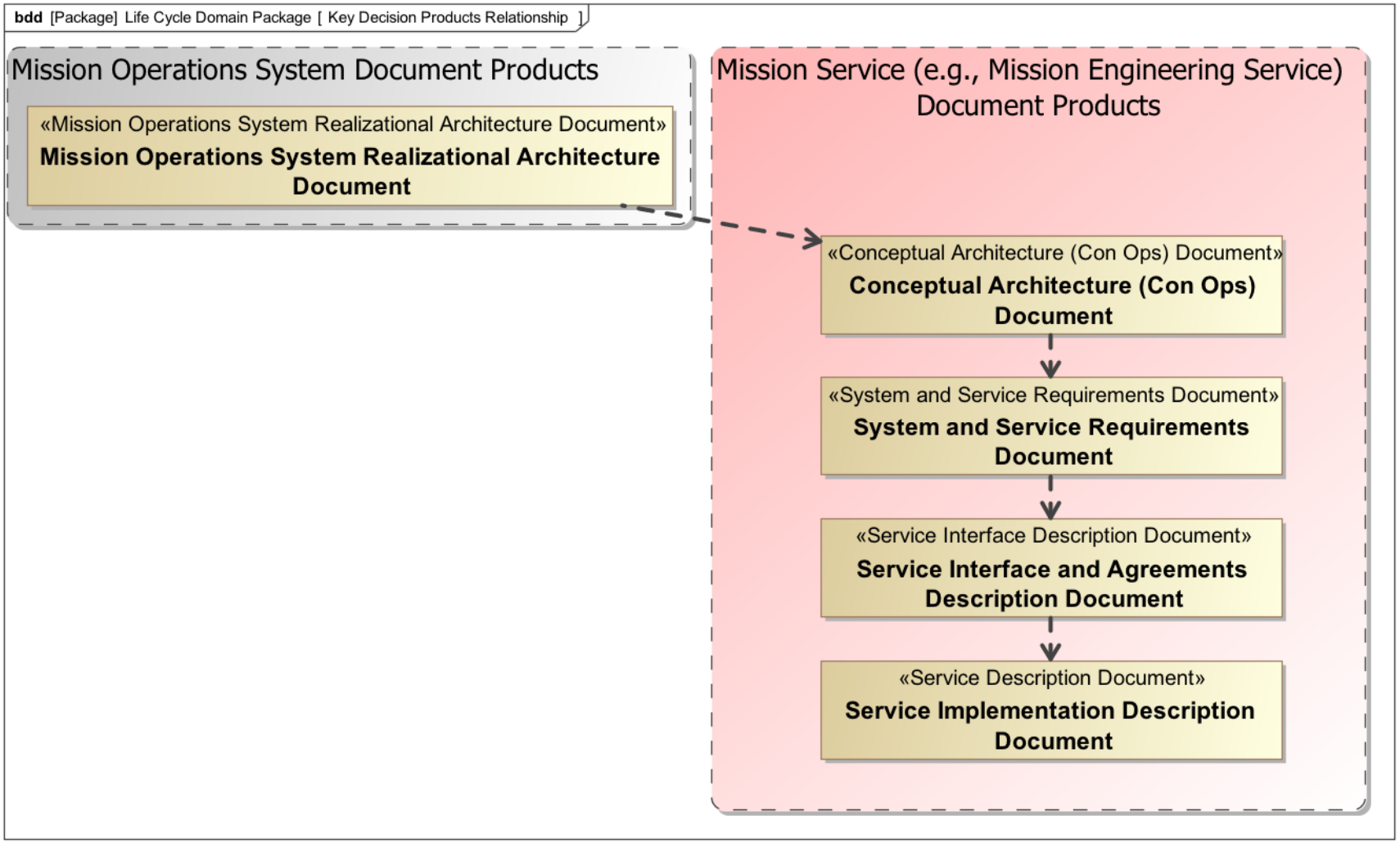


# Business Case: IT-Process Alignment

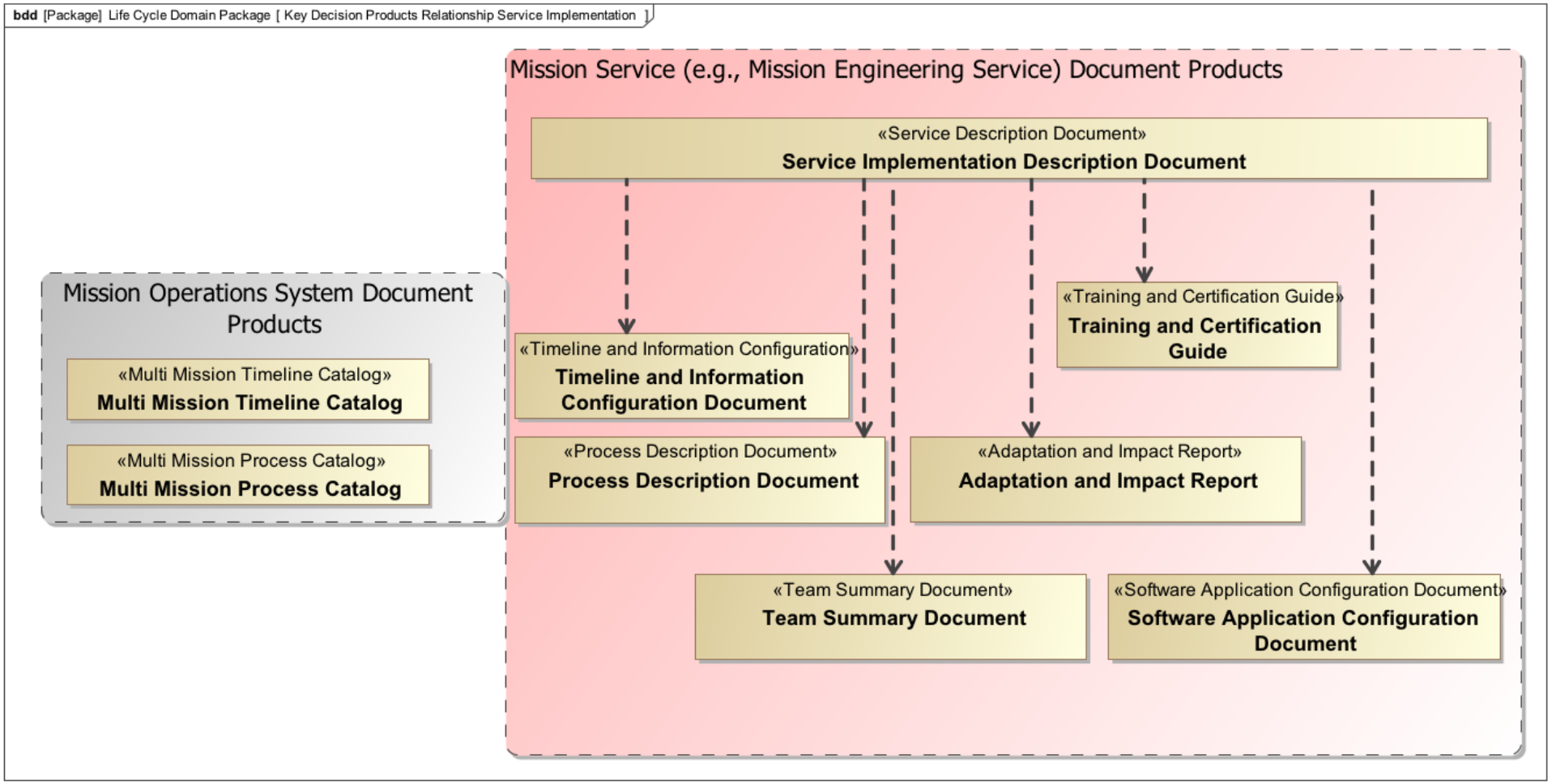



*Source: London School of Economics – McKinsey survey and analysis of 100 companies in France, Germany, UK and US*

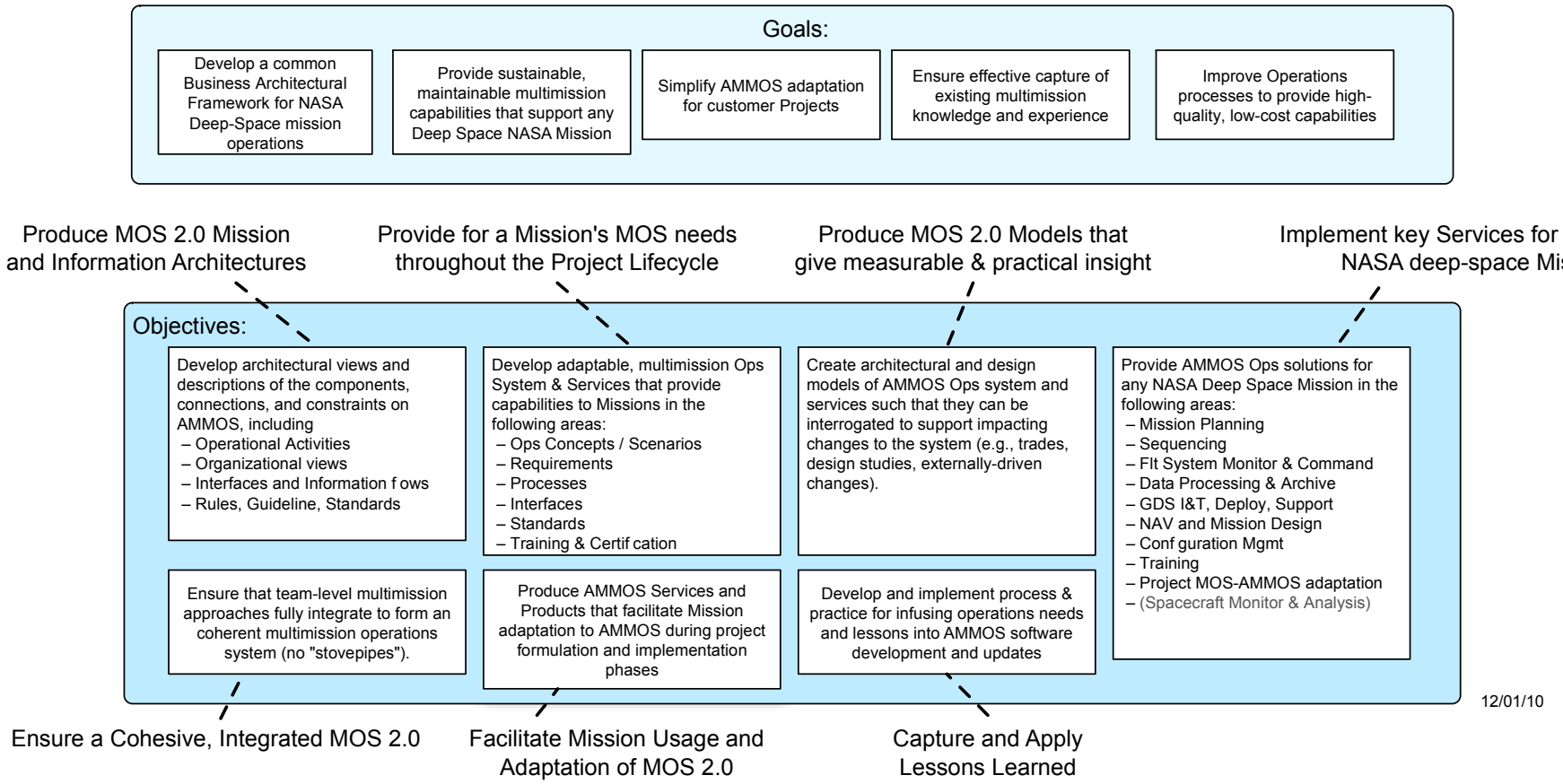
# Architecture Products



# Architecture Products



# Establish Goals & Objectives



# Adopt Principles

- Principles guide the system
  - "Moral guidance" for design and implementation
  - Not requirements

| | |
|---|---|
| – Primacy of Principles | – Technology Independence |
| – Close The Loop | – Universality of Information Security |
| – Customer Focus | – Use of Common Services |
| – Info Accessibility | – *MOS is a Control System* |
| – Interoperability (open standards | – *Develop With What You Fly With* |
| – Learn from Experience | |

# Next Steps / Future Plans

- Implementing Mission Services for MOS
  - Multi-mission (adaptable) designs
- Collaboration/support of AMMOS S/W efforts
  - SEQR, ISCA, IMS, TMS…
  - Information and process architectures are key connection points
- Collaboration with APL Ops community
- Process facilitation & automation
  - BPM, process “dashboards”
  - DocGen/DocWeb for model-based docs


# Ops Revitalization Team

- **Current**
- Duane Bindschadler (930)
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- Marc Sarrel (318)
- Rob Smith (318)
- Seung Chung (313)
- Chris Delp (313)

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

*And Stakeholders too numerous to list…*