Next-Gen Mission Operations Systems: Architectural Considerations

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Challenge for JPL / AMMOS

- Build an enduring MOS architecture to support missions that
  - Are long-duration (years to decades)
  - Are highly customized / optimized
    - Unique hardware
    - Unique software
    - In unique environments
  - Are science-driven
- While keeping cost and risk to a minimum

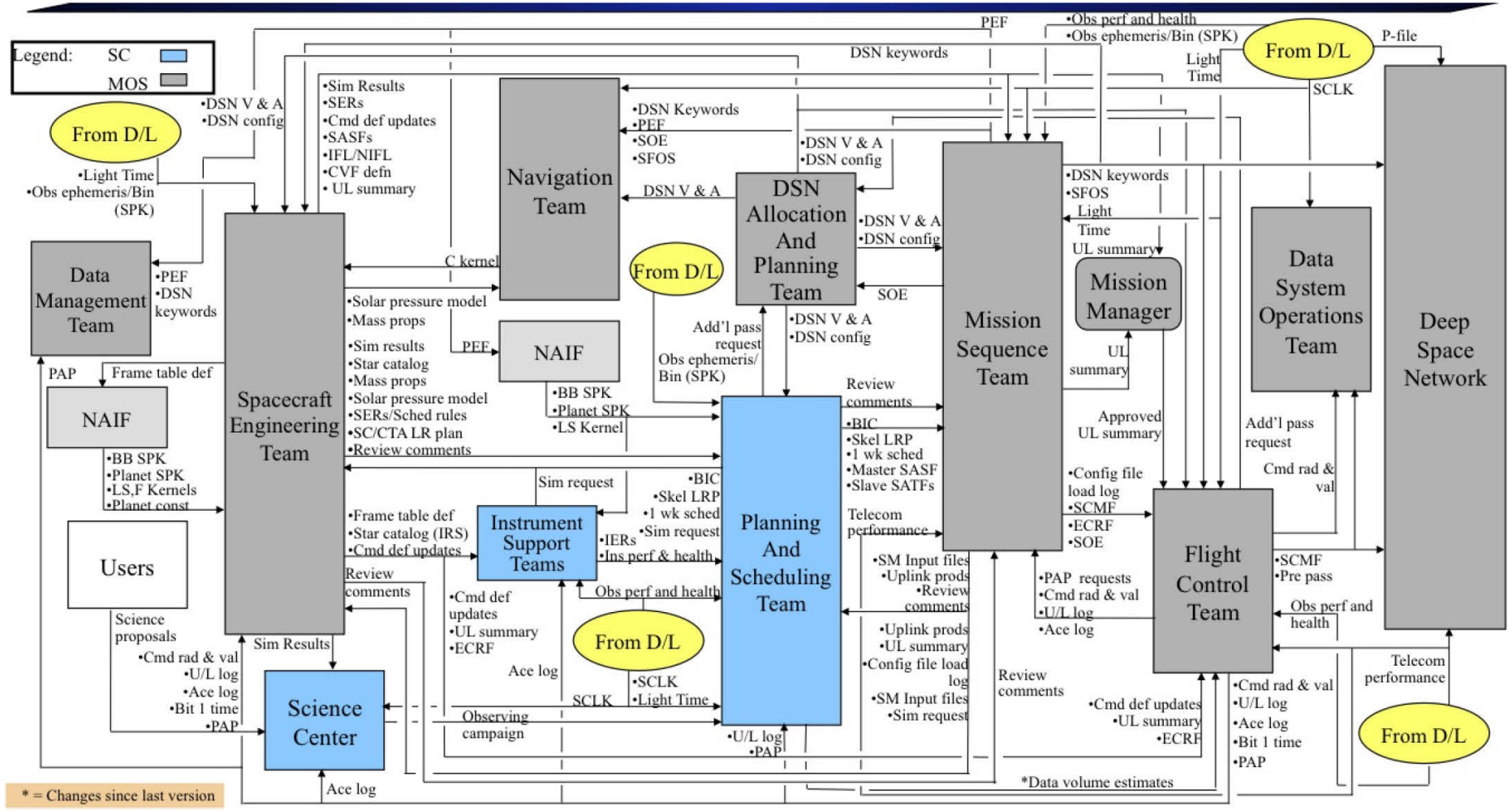
Cost-Driving Issues

- "Operations Systems just do Planning and Processing" (a.k.a. Uplink & Downlink)
  - Waterfall mentality
  - Organizational & conceptual "stove-piping"
  - MOS is "just a bunch of documents"
- Lack of explicit understanding of relationships between software & process
- File-based information model is inefficient & drives maintenance costs
- ***Lack of clarity about the central purpose of a Mission Operations System***

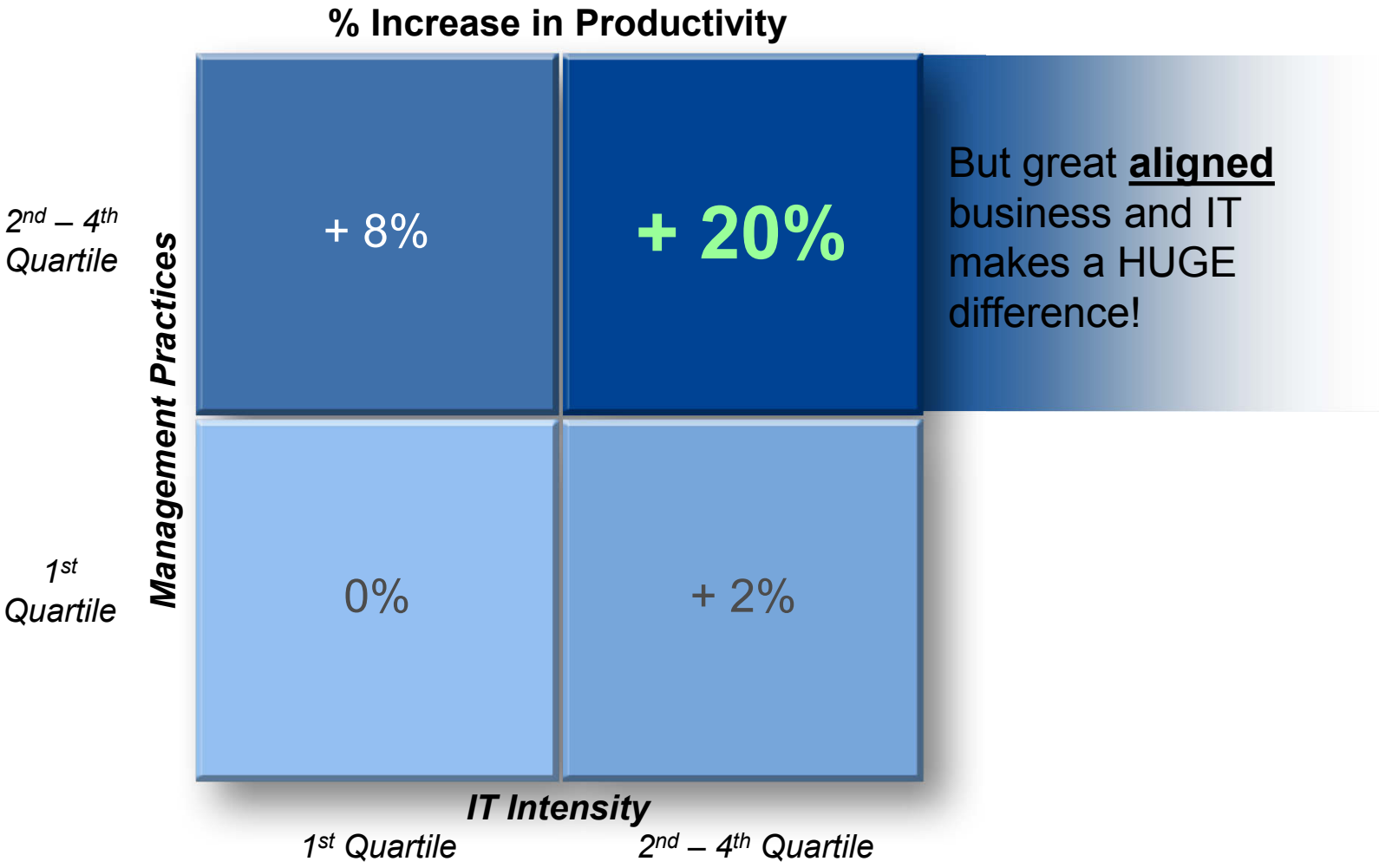
Technical Driving Issues

- Increased complexity of mission concepts
  - Planetary sample return, surface environments
  - ***Multi-spacecraft coordination***
  - ***Joint human-robotic missions***
  - Multi-Nation / -Agency collaborations
- Desire for more flexibility
  - Enable science decisions as late as possible
  - Flexibility to transfer control between flight and ground systems
- Onboard autonomy
  - More functionality onboard
  - Migrate ground functions up to flight systems
- Desire to exploit new software technologies

Current System View



Improved Process and IT Makes a Difference…



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

Future System

MOS 2.0

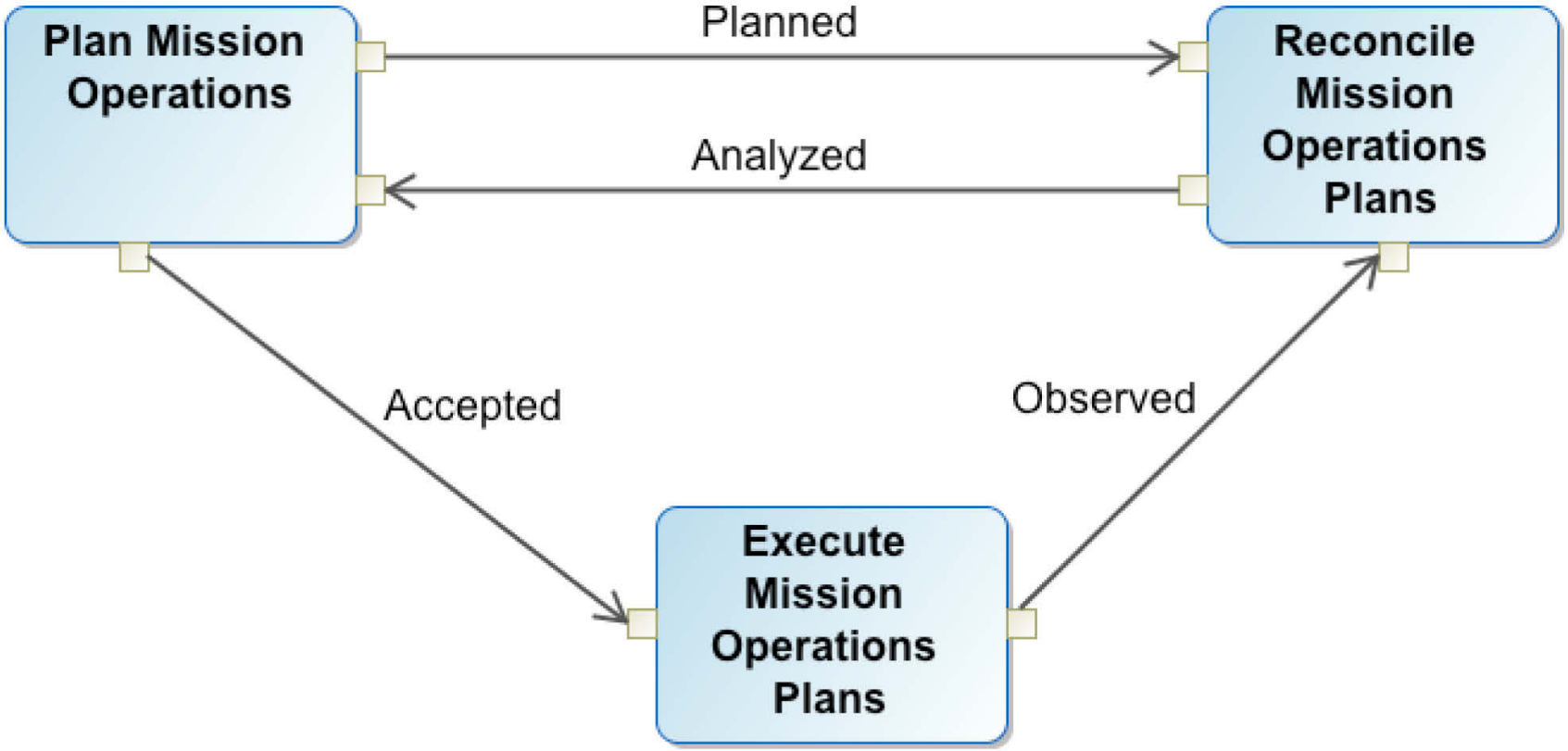
- Principles guide the system
  - "Moral guidance" to guide design choices and implementation
  - Not "shall" statements

– 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	

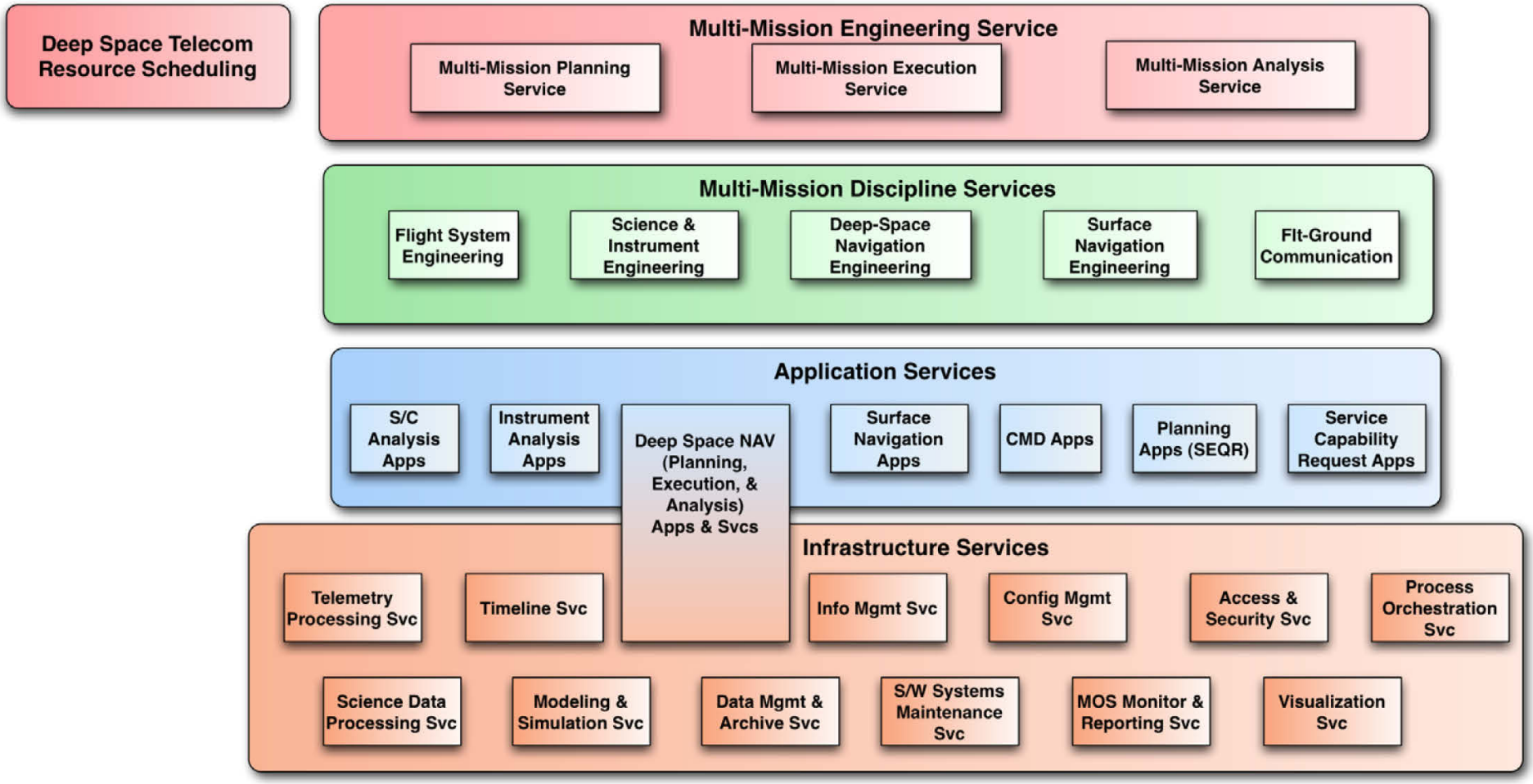
Control Service Architecture

- Control System
  - Primary purpose of and pattern for MOS and components
- Timeline
  - Pattern for information products of MOS
  - Defines scope of control for each Service
- Service
  - Pattern for how MOS does its job
- Queues
  - Pattern for measuring the performance of MOS

Control System Pattern

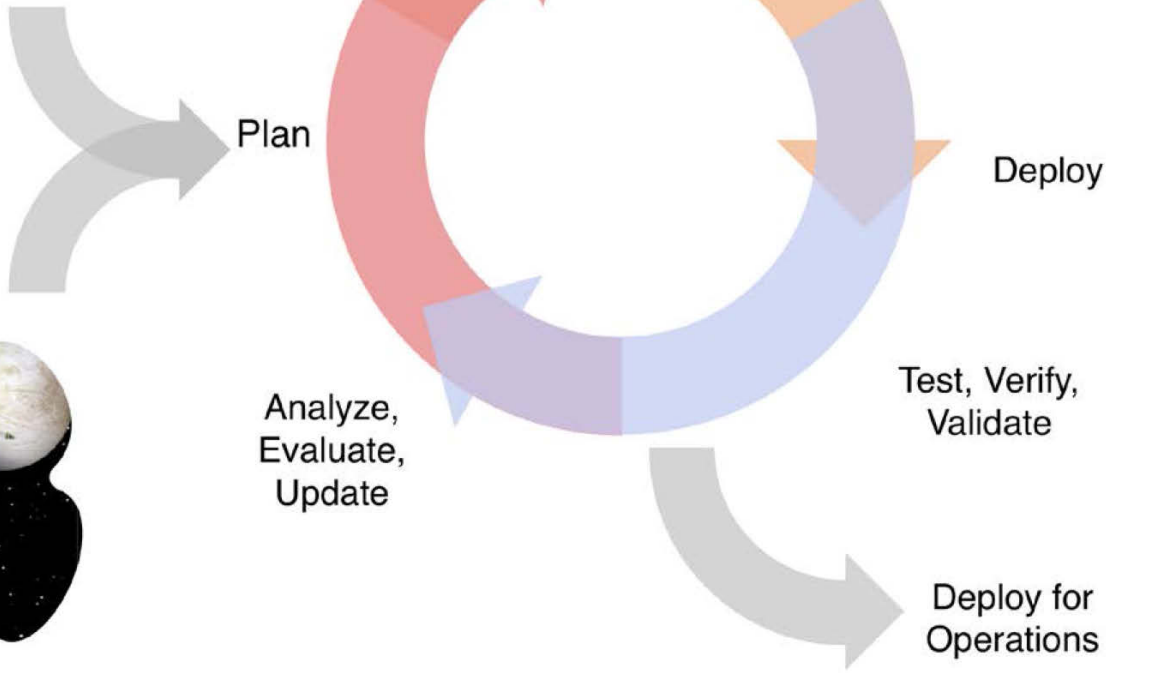


MOS 2.0 Services



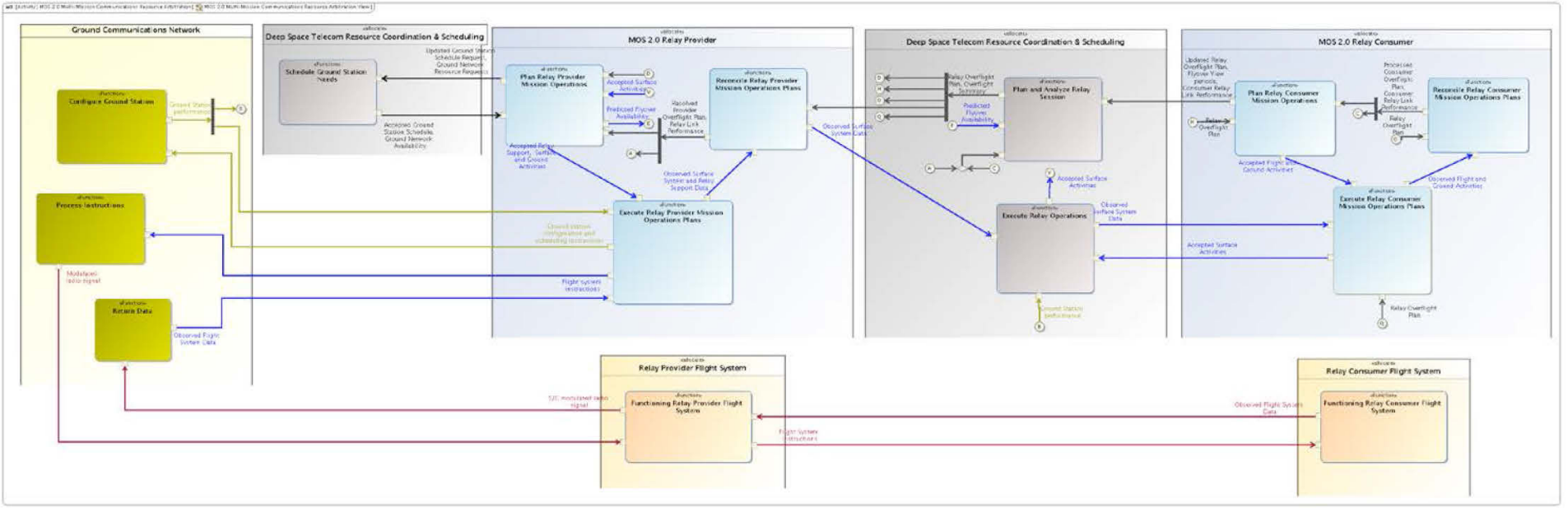
To-Be: “Develop with what you fly with”

MOS 2.0 Framework

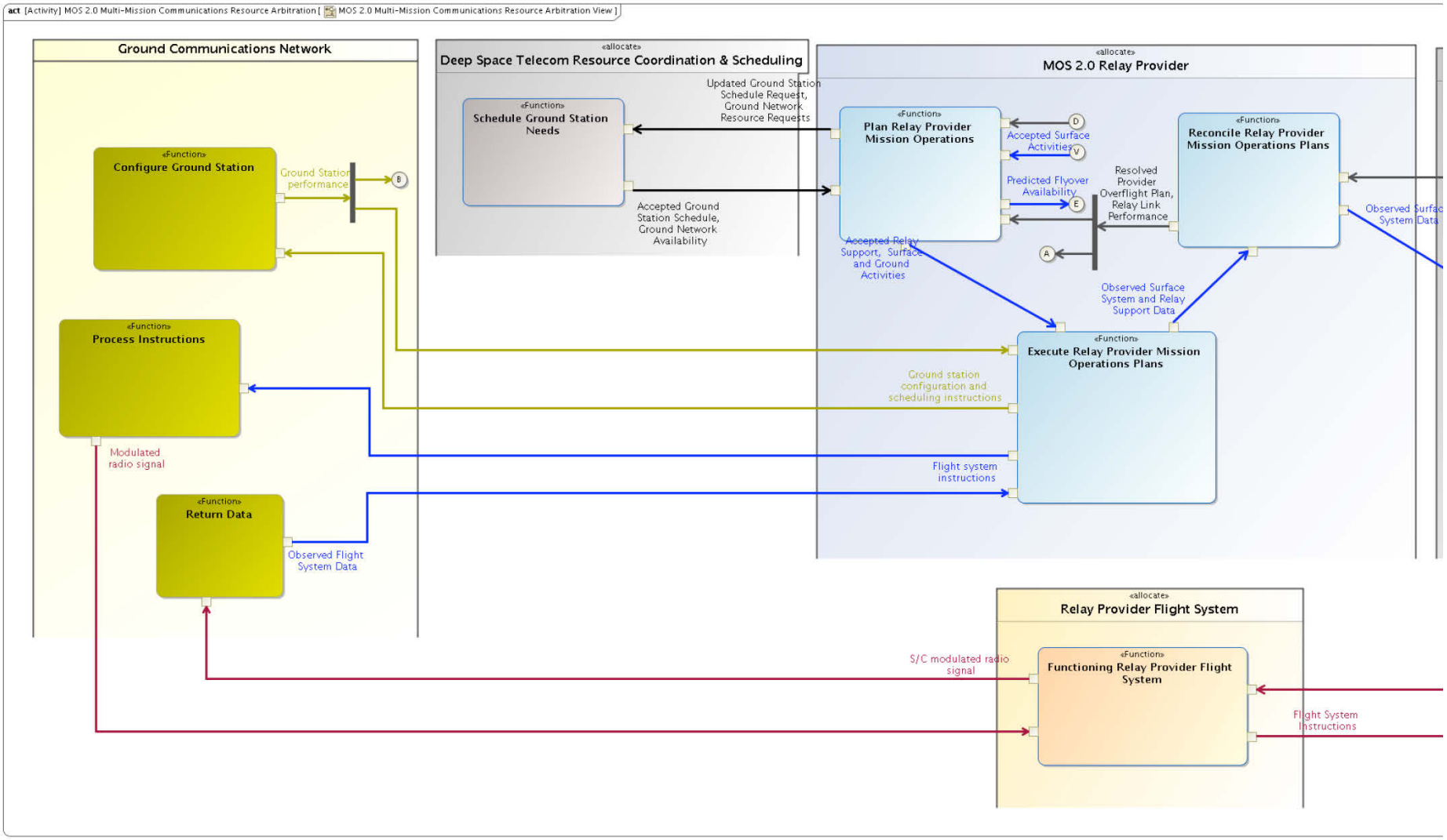


Multi-Mission Coordination: System-of-Systems

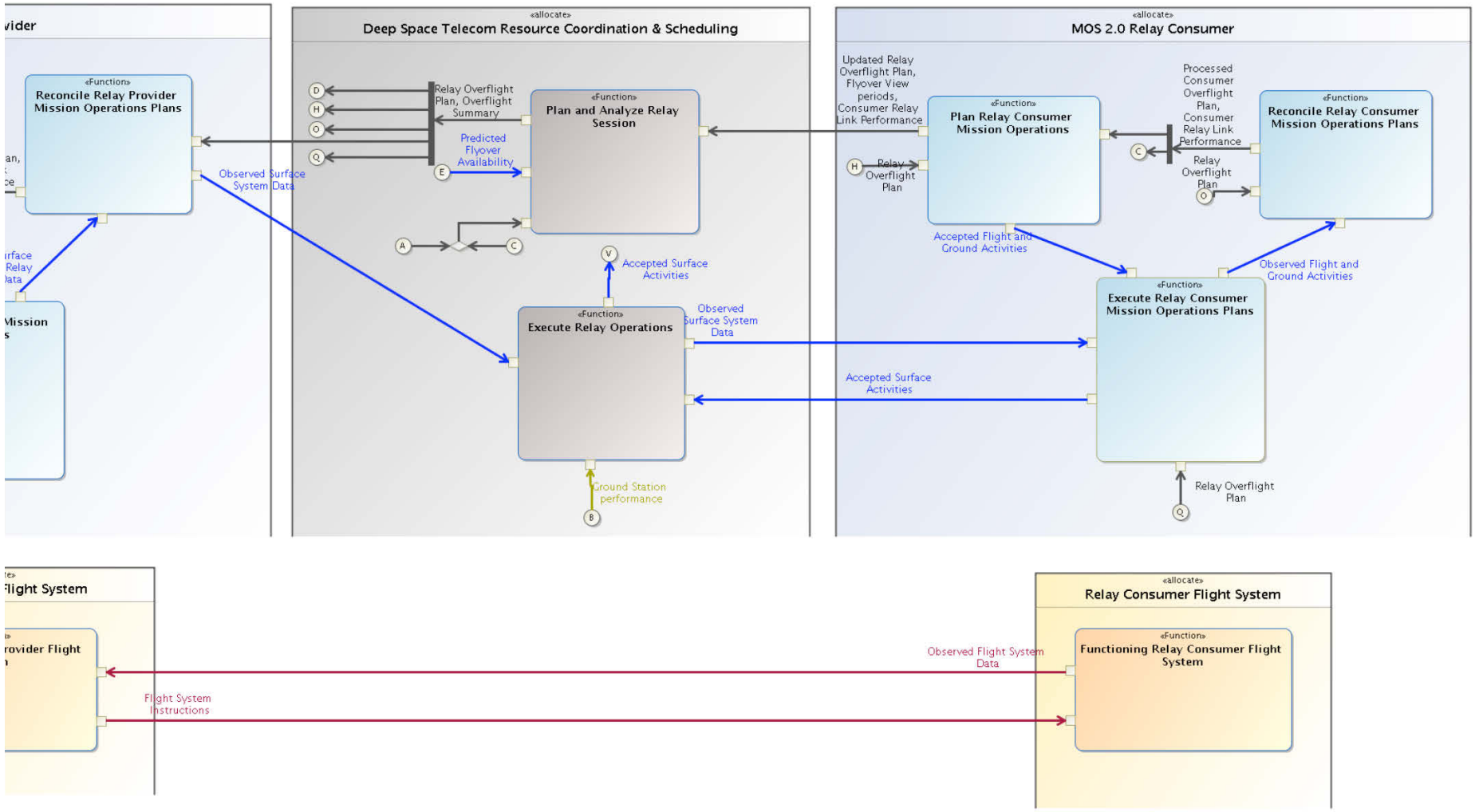
Relay Coordination



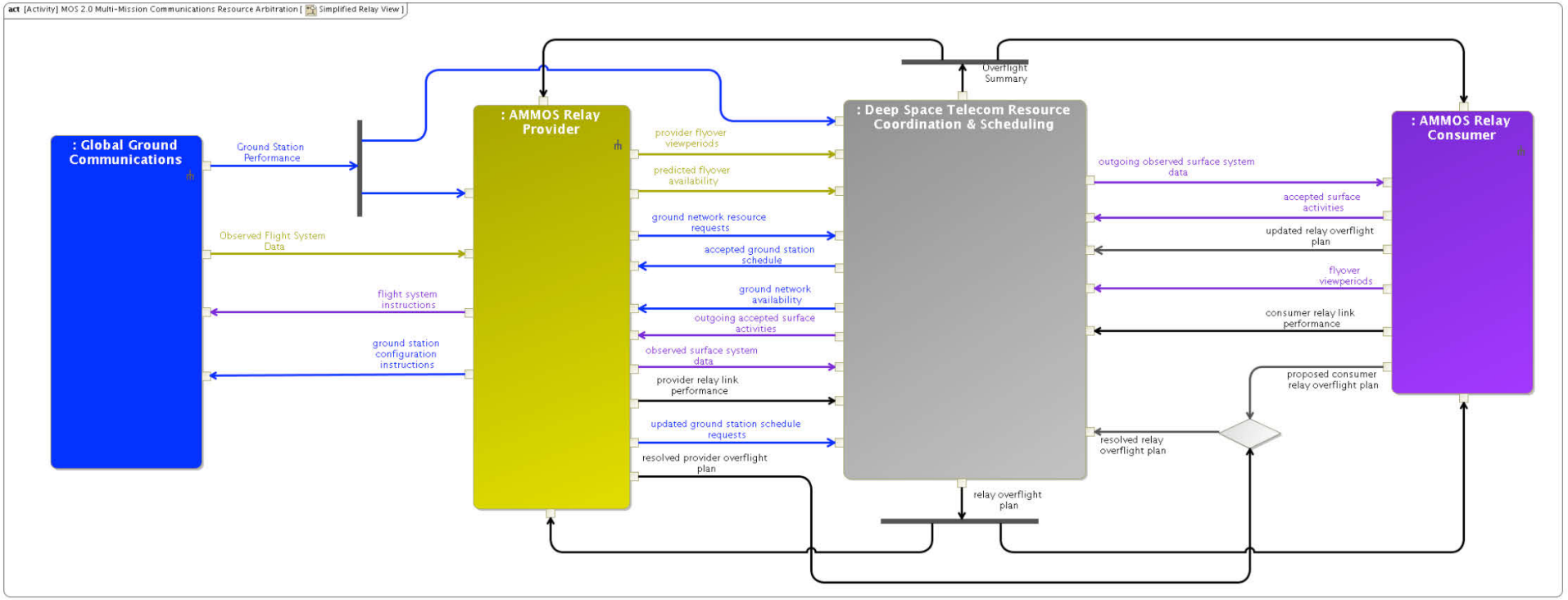
Relay Diagram (left side)



Relay Diagram (right side)



Focused Interactions View



Summary

- Next-Gen MOS architecture
  - Principled
  - Closed-loop Control System
  - Timeline Information Model
  - Service-Oriented
  - Facilitates creation of coordinated system-of-systems

Backup

Current System