SYSTEMS ENGINEERING INTERFACES: A MODEL BASED APPROACH

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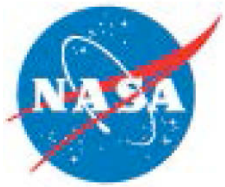


Context

- AMMOS:
  - Advanced Multi-Mission Operations System
  - Product line: Adaptable tools and services for operating NASA's robotic missions
  - Key advantage: Cost and Risk
- Operations Revitalization Task
  - Enhance, extend multi-mission operations
- MOS 2.0
  - The Next-Generation Mission Operations System

The Flight Ground Interface

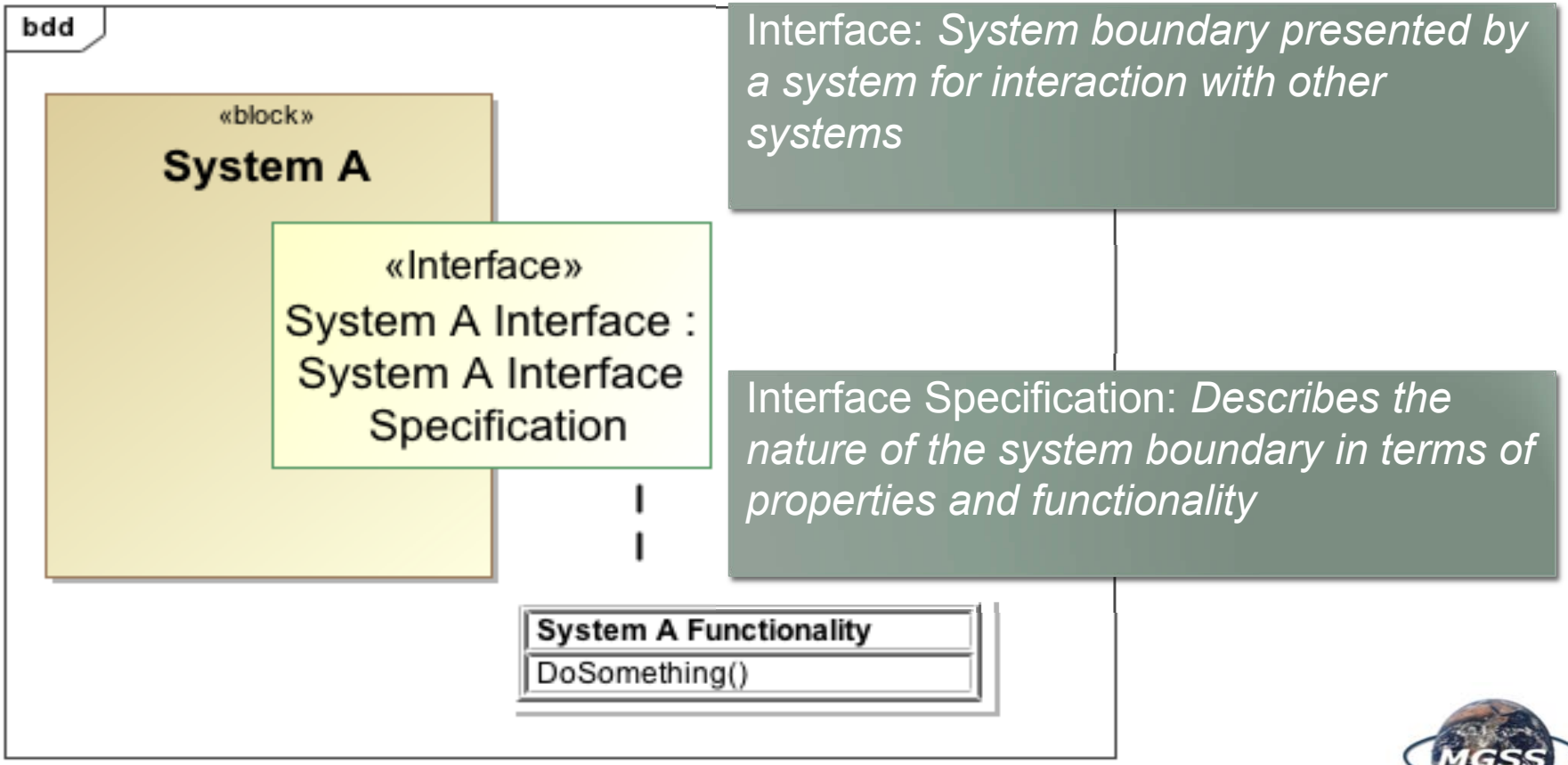
- Key interface for Mission Operations Systems Engineers(MOSE)
- Focuses on the interaction between:
  - An operational flight system
  - The MOS located on the ground
- The MOSE needs to understand:
  - Allowable information exchange
  - Allowable behavior between the flight system and the MOS
  - Operational constraints: timing, quality of product
  - To name a few

Flight Ground Interface Description

- An MOSE relies on documents and diagrams to describe the specification of the Flight Ground Interface.
- Ops Rev created a framework consisting of:
  - Interface-specific language (extending from SysML)
  - Patterns for modeling interfaces and instances of interaction
  - Viewpoints for addressing specific concerns related to interface engineering
    - The MOSE can focus on the systems engineering work related to interfaces and the needed document/presentation artifacts can be generated from the model.
- Ops Rev implemented to framework to describe the Flight Ground Interface

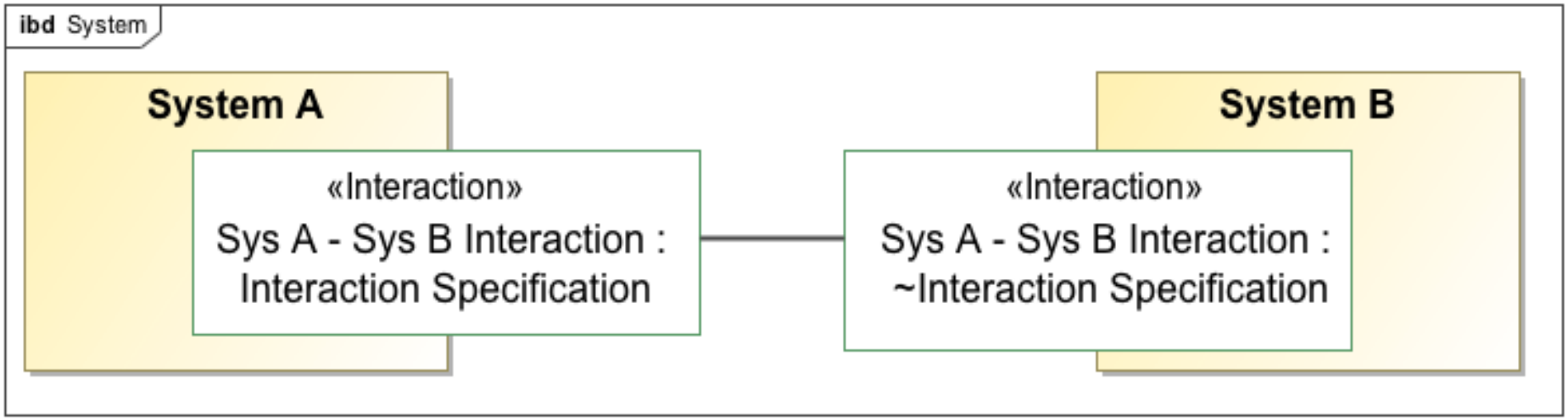
Interface Engineering with SysML

Provides a precise model-based representation for specifying interfaces



Interaction Engineering with SysML

Provides a precise model-based representation of integration of parts through interfaces

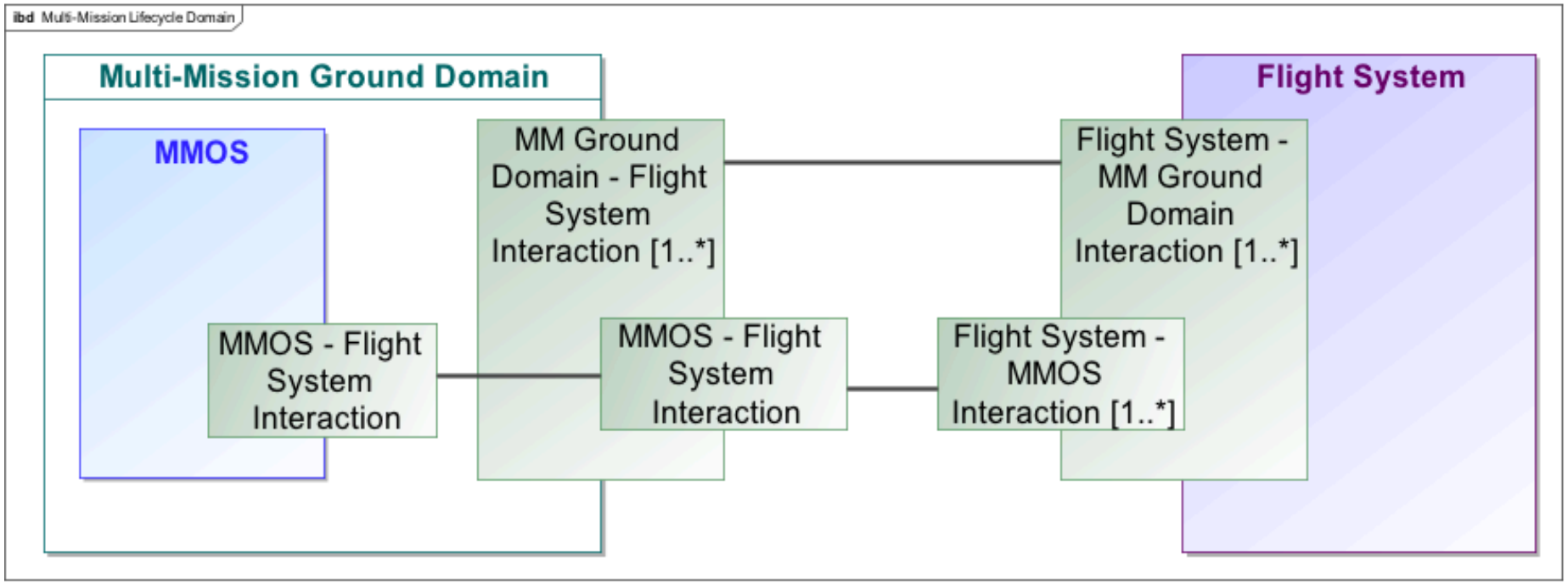


Interaction: *An instance of an interface*

Interaction Specification: *Describes how two or more system boundaries can connect and effect one another*

Interface Connection View

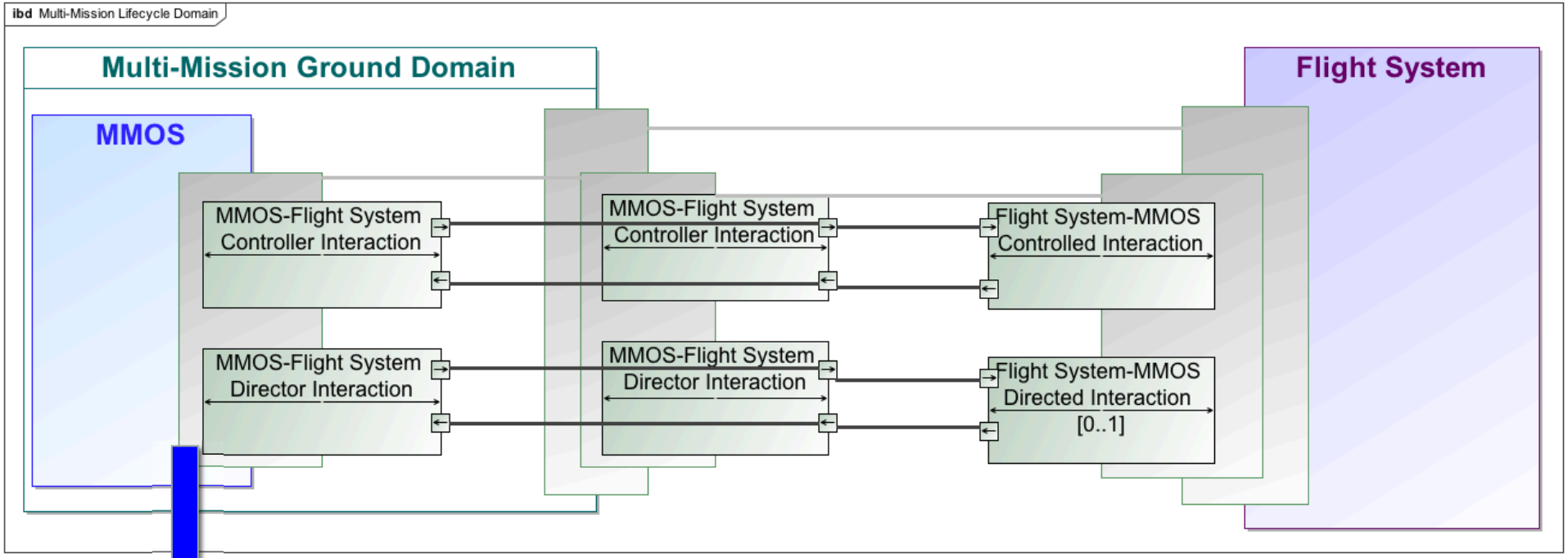
What parts are connected to each other?



MMOS delegates its functionality to the ground domain in order to interact with theoperational flight system

Interface Object Flow View

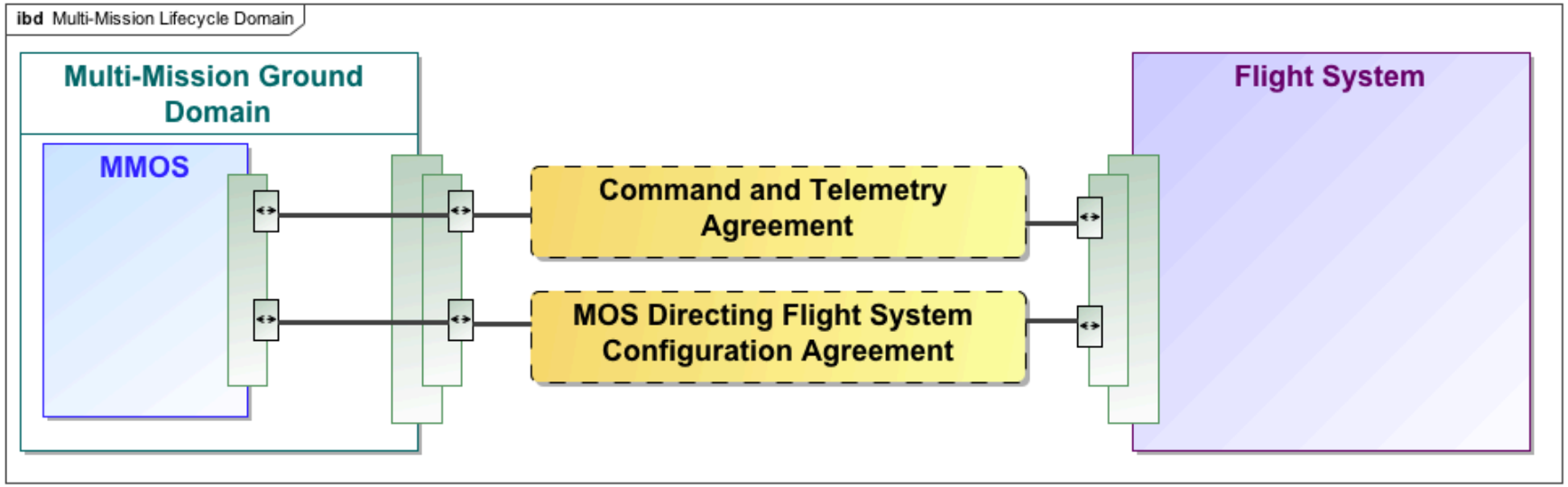
What are the flows between parts of the system?



MMOS-Flight System Interaction Specification	Inputs	Outputs
MMOS-Flight System Control Interaction Specification	Flight System Telemetry	Flight System Commands
MMOS-Flight System Director Interaction Specification	Flight System Configuration Telemetry Flight System Command History	Flight System Configuration Loads Flight System Ephemeris Loads

Performance and Limitations View

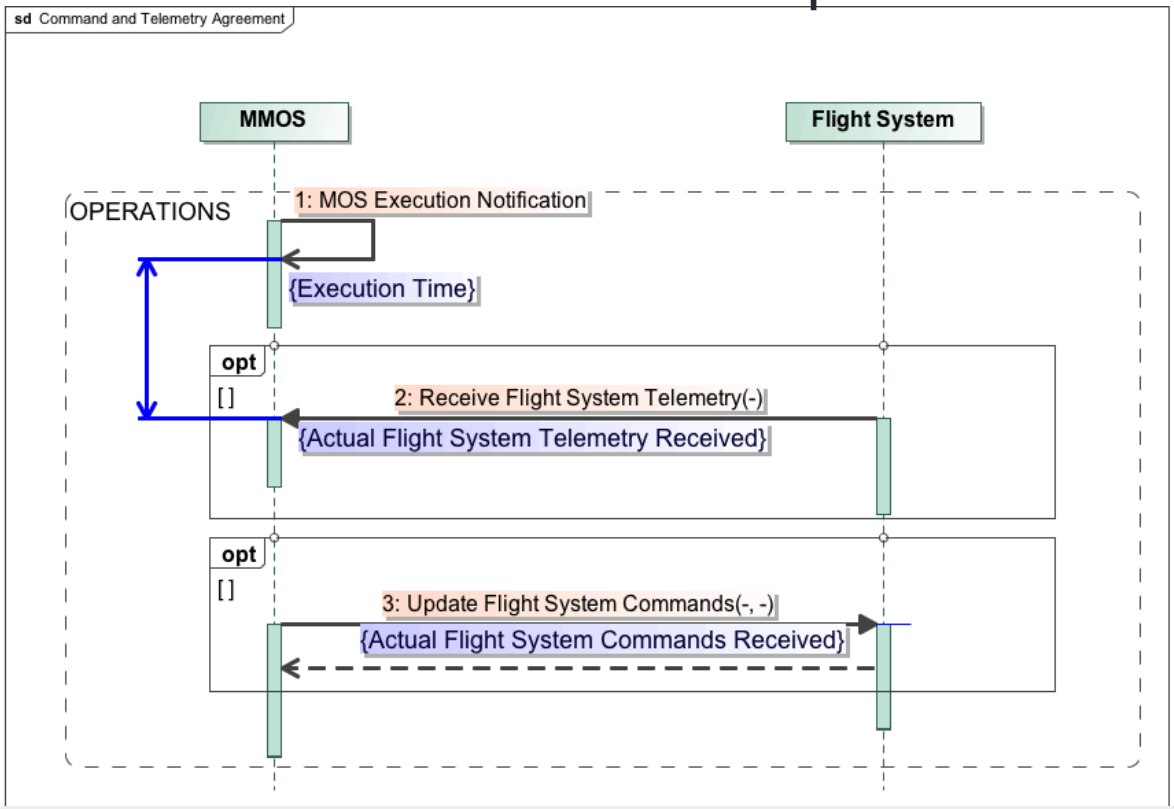
What are the expectations and limits of the given interaction



Agreement	Producer	Consumer	Products	Responses	Frequency	Duration	Quality
Command and Telemetry Agreement	MMOS	Operational Flight System	• Flight System Commands	• Flight System Response • Telemetry			
MOS Directing Flight System Configuration Agreement	MMOS	Operational Flight System	• Flight System Configuration Commands • Flight System Configuration File	• Flight System Response • Telemetry			

Function Occurrence View

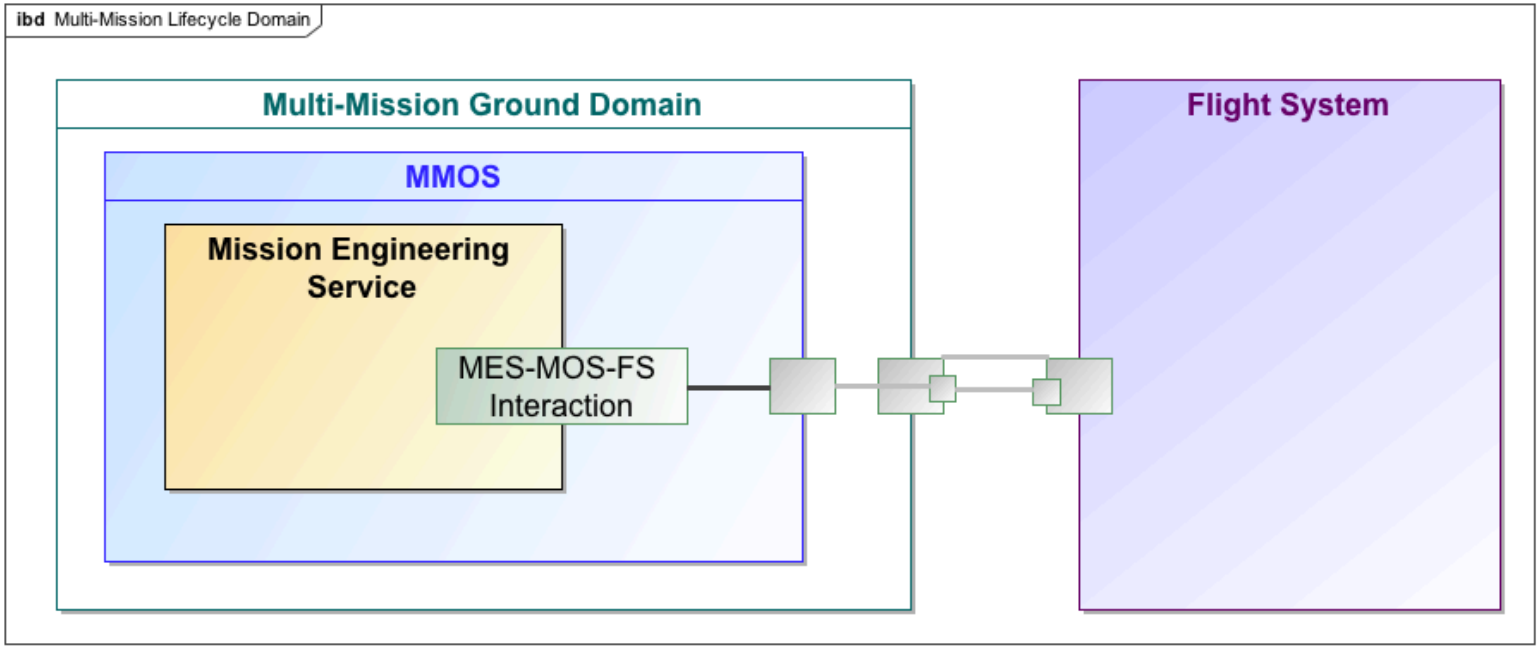
How do functions occur between parts of the system?



Event(Function Occurrence)	Inputs	Outputs
Receive Flight System Telemetry	Telemetry	
Update Flight System Commands	Flight System Commands	Flight System Response

Interface Delegation View

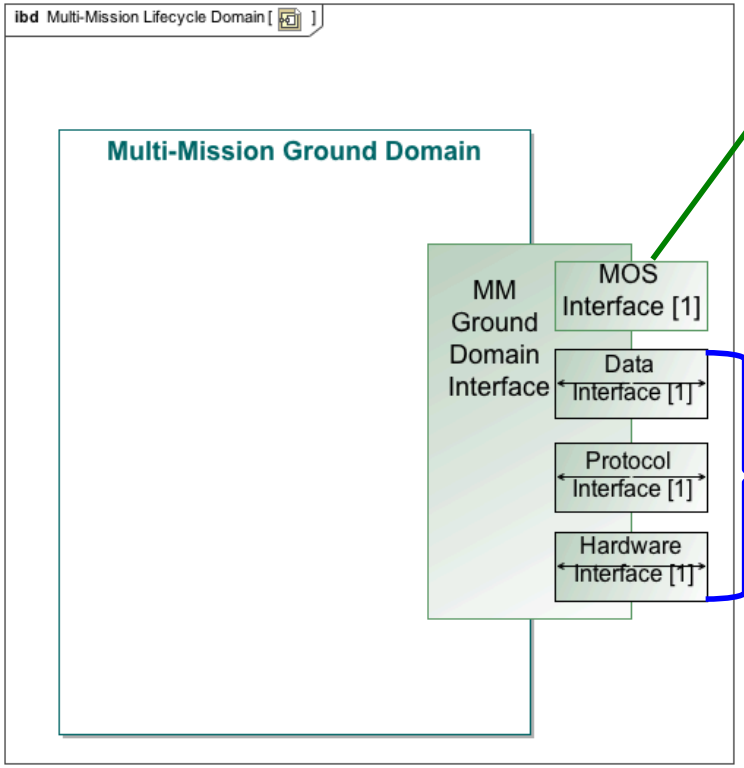
MMOS delegates to Mission Services for functionality fulfillment



Mission Services are discipline-specific functionality groupings

Interface patterns used for MMOS and Flight System are applied at the Mission Service level as well

Other Interface Layers



The focus of Ops Rev and its interface engineering implementation is on the business layer

The same methodology and Viewpoints can be used to express the specifications of the other layers:

- Data: elaborates information identified in the business layer into the actual data to be transferred to the Flight System
- Protocol: translates into the standards-compliant protocol stacks
- Hardware: allocates software functionality to specific hardware

Approach Advantages (1 of 2)

Ask questions of the model and get reportable answers

SE Verification	Model Interrogation
Is the connection between 2+ parts valid with respect to information?	Check that all SysML ports connected to each other of the same (or specialized from the same) type?
How many interfaces exist without connections to other parts?	Find all interfaces with no connectors
Is the connection between 2+ part valid with respect to the framework patterns?	Check that all SysML ports are either connected by a constraint property (agreement) or have parent port that are connected by a constraint property (agreement)

Approach Advantages (2 of 2)

- Automation
  - The interface model can be queried and replicated in an automated fashion to provide instances of interaction
- A core set of reusable Viewpoints
  - Allows for document and presentation artifacts to be generated directly from the model
  - The MOSE can focus on the engineering content of the model
  - The reviewer can focus on how the Mission-specific view responds to the concerns of the Viewpoint.

Approach limitations

- In SysML 1.3 there is not a good way to trace functionality of a system across its interactions
  - The sequence diagram elements have no direct connection to the interface ports
- SysML 1.4 was released and introduces refinements to port specifications

Summary and Next Steps

Currently:

- Ops Rev developed and maintains a framework that includes interface-specific language, patterns, and Viewpoints
- Ops Rev implements the framework to design MOS 2.0 and its 5 Mission Services
- Implementation de-couples interfaces and instances of interaction

Future:

- A Mission MOSE implements the approach and uses the model based artifacts for reviews
- The framework extends further into the ground data layers and provides a unified methodology.