

# Low Cost Automated Ground Segment for EO, Science & Telecoms Missions



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# Overview

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2. [Standards-Based Open Architecture](#)
3. [Integrated Automation](#)
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# Mission Operations Cost Drivers

- Earth Observation
  - ⇒ Pass-based operations – one or many passes per day
  - ⇒ Man-power intensive for short periods
- Science
  - ⇒ Specialised operations teams (Spacecraft and Science ops)
  - ⇒ Long operations tail ->>
- Telecommunications
  - ⇒ High reliability operations
  - ⇒ Fleet operations
  - ⇒ Strong commercial pressure to reduce all costs

Mission	Nominal Life (Months)	Extension (Months)	Increase
Cassini-Huygens	57+48	-	-
Cluster II	60	48	80%
Integral	24	36/72	200/300%
Mars Express	22.6	22.6	100%
Rosetta	140	-	-
SOHO	24	120	500%
SWIFT	24	60	250%
SMART-1	24	12	50%
Ulysses	48	168	333%
Venus Express	16	24+	150%
XMM	24	72/96	300/400%



## Low Cost?

- Our objective is to minimise costs across the Lifecycle for all the Mission Operations (MO) components
- Low cost to:
  - ⇒ Procure –Low-Cost Platforms and Software Components
  - ⇒ Tailor for your system – Choose the components you want
  - ⇒ Operate – Integrated Automation of Ground and Space Segment
  - ⇒ Maintain and Extend – Open interface so you can add your components
- Standards-based approach to Spacecraft Monitoring & Control
- Avoids proprietary solutions

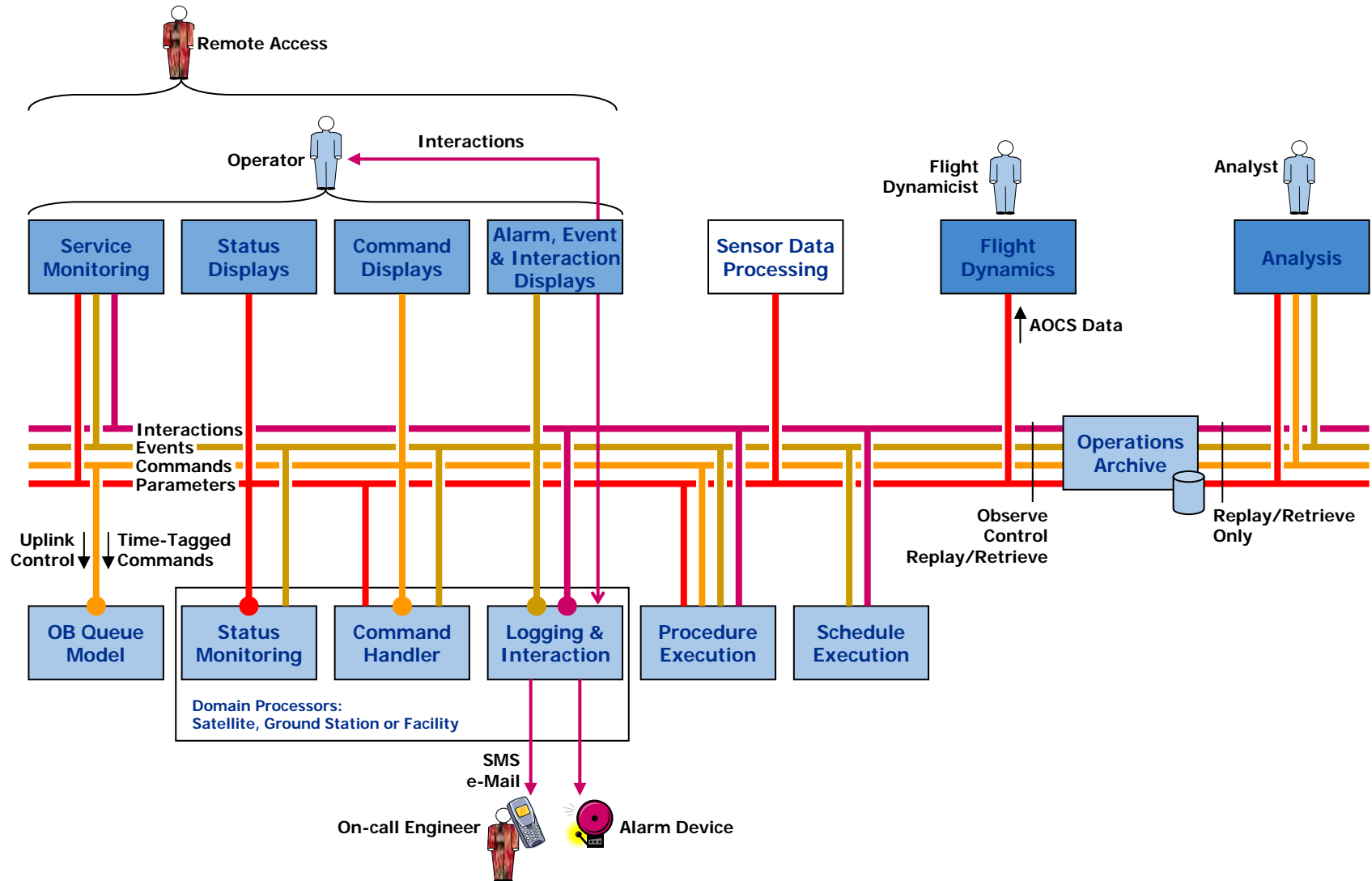


# CCSDS Spacecraft Monitoring and Control

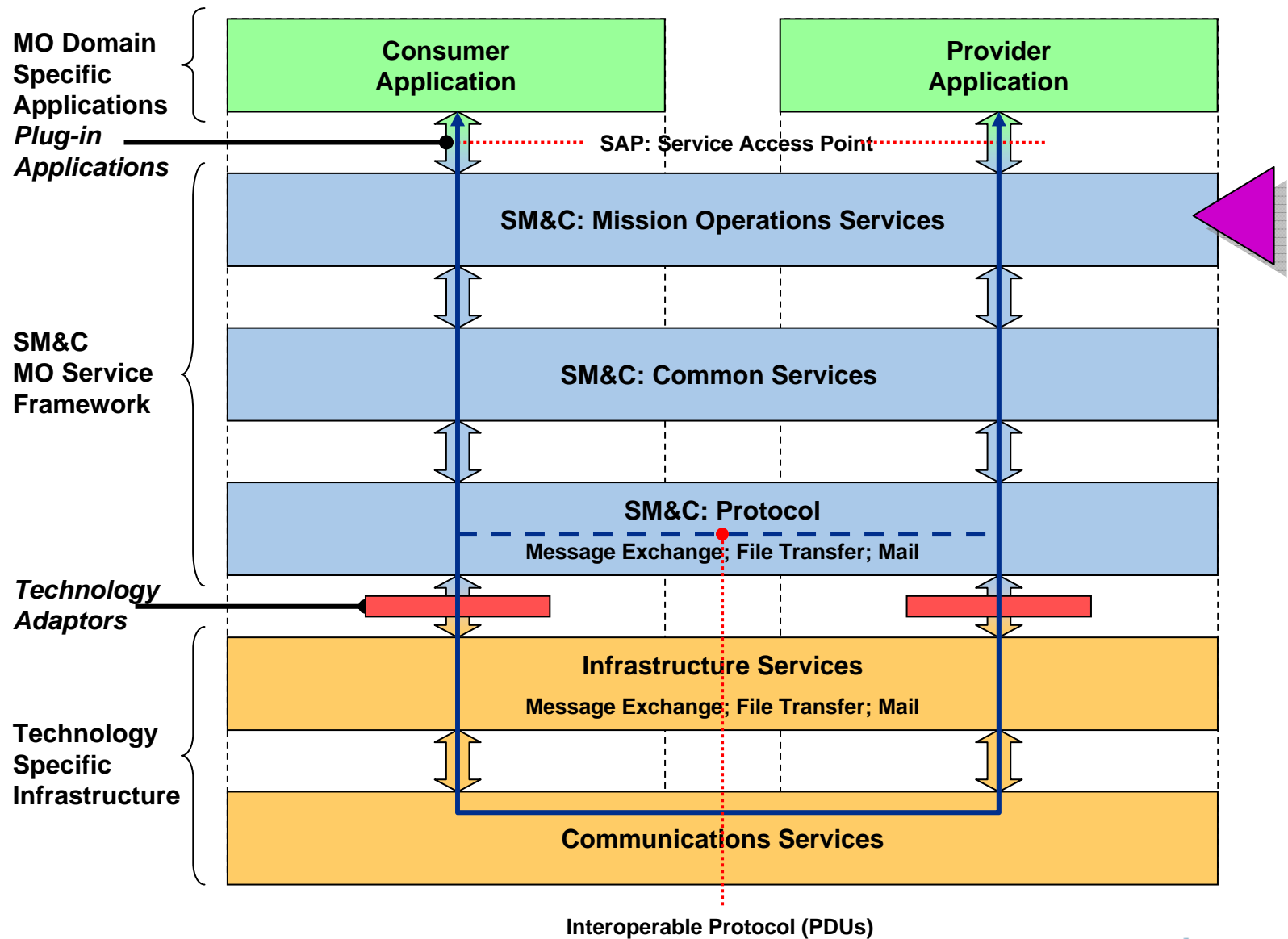
- CCSDS SM&C Working Group
- Covers all services that are needed to monitor and control a remote system including:
  - ⇒ Classical TM monitoring
  - ⇒ TC generation (manual, pre-planned, automatic, time-tagged, ...)
  - ⇒ Remote software management
  - ⇒ Time management
  - ⇒ Mission product data management
  - ⇒ Mission planning and automation
  - ⇒ Orbit and Attitude determination
  - ⇒ Position determination
  - ⇒ Standard interaction with the operator
  - ⇒ ... more to come
- Does not prescribe the system architecture and functionality
  - ⇒ Service provider/consumer could be located differently depending on the specific deployment
  - ⇒ No predefinition of application implementation only of its interface
- Must allow expansion to future needs



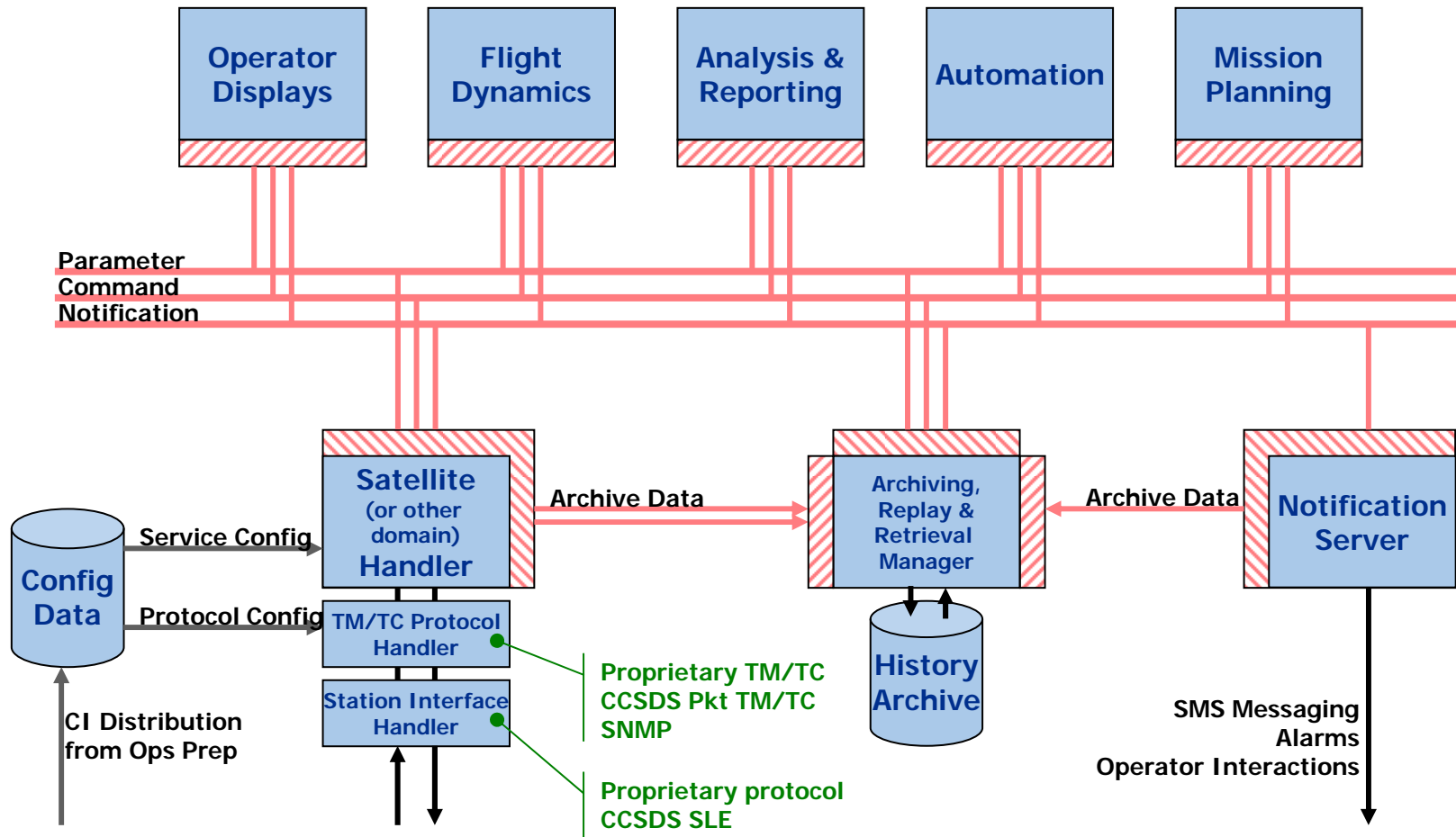
# Core M&C Services - Service Bus Concept



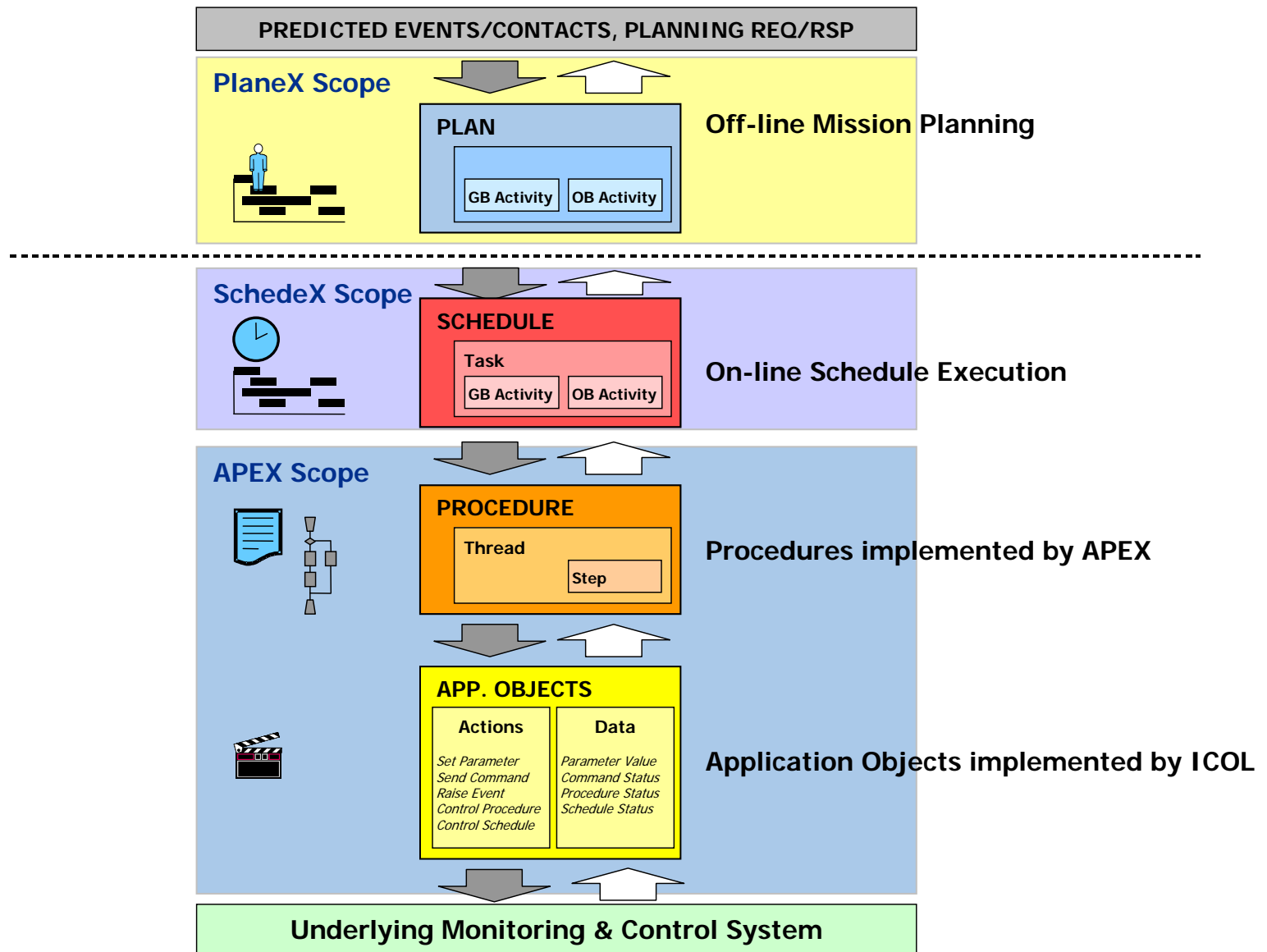
# SM&C Service Layering



# Service Based SCS Architecture (Core M&C)



# Integrated Automation

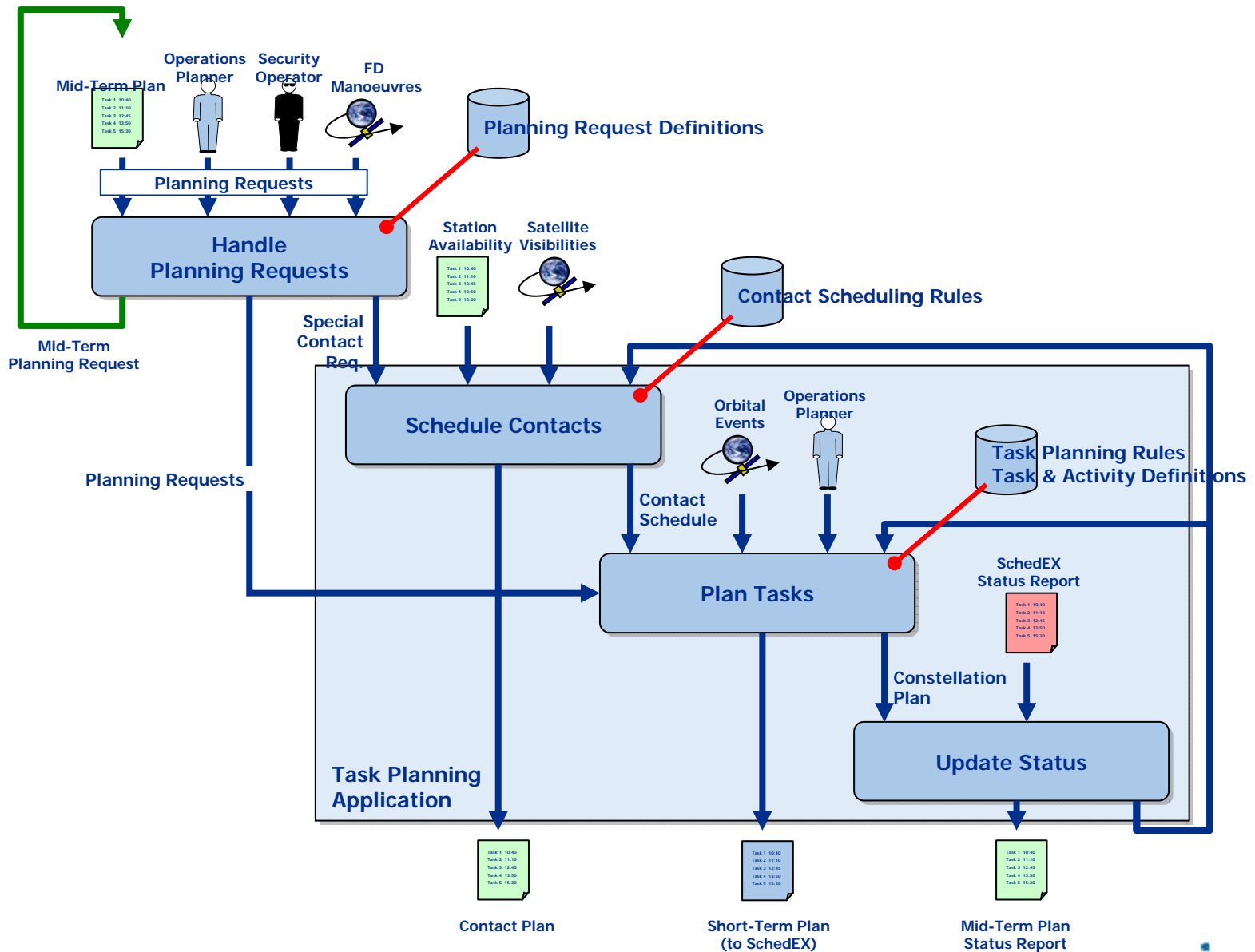


# Mission Planning - PlanEX

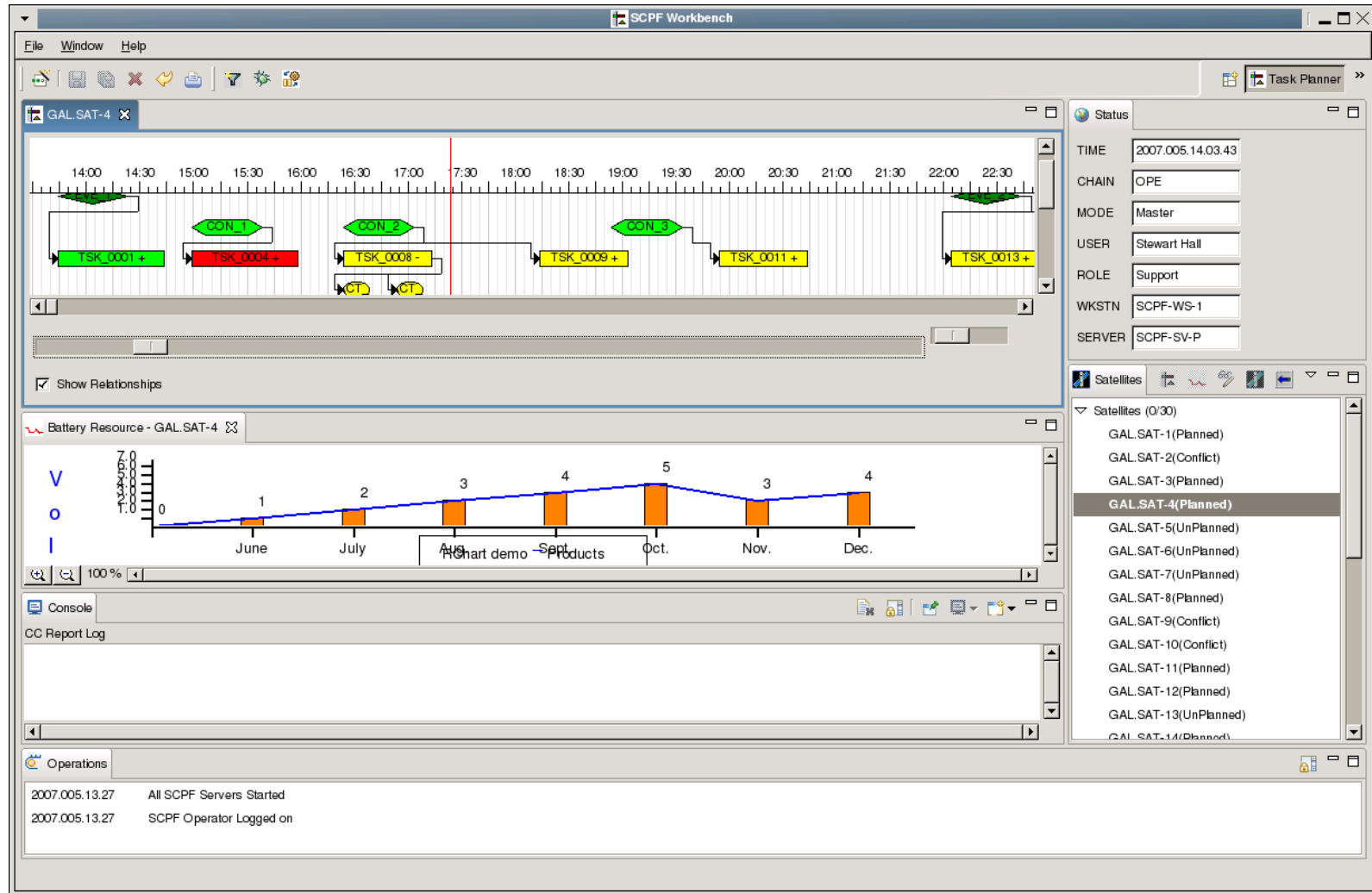
- Preparation of a set of self-contained planning tasks e.g.:
  - ⇒ Update of current Mission Plan status by reference to Schedule Execution Feedback from the Operations Automation component.
  - ⇒ Roll forward Mission Plan to current time.
  - ⇒ Load new Orbital Events from Flight Dynamics.
  - ⇒ Process new Planning Requests received, placing new operational tasks in accordance with defined Trigger Rules.
  - ⇒ Check Temporal and Exclusion constraints and resolve conflicts where flexibility in time constraints permit.
  - ⇒ Propagate Resource Vector and check resource constraints, resolving conflicts where flexibility in time constraints permit.
  - ⇒ Resolve any residual conflicts interactively with the Mission Planner.
  - ⇒ Generate schedule update and release to Schedule Execution.
- Multi-mission/multi-domain
- Java-based for portability



# PlanEX: Component Architecture



# PlanEX: Task Planning Display

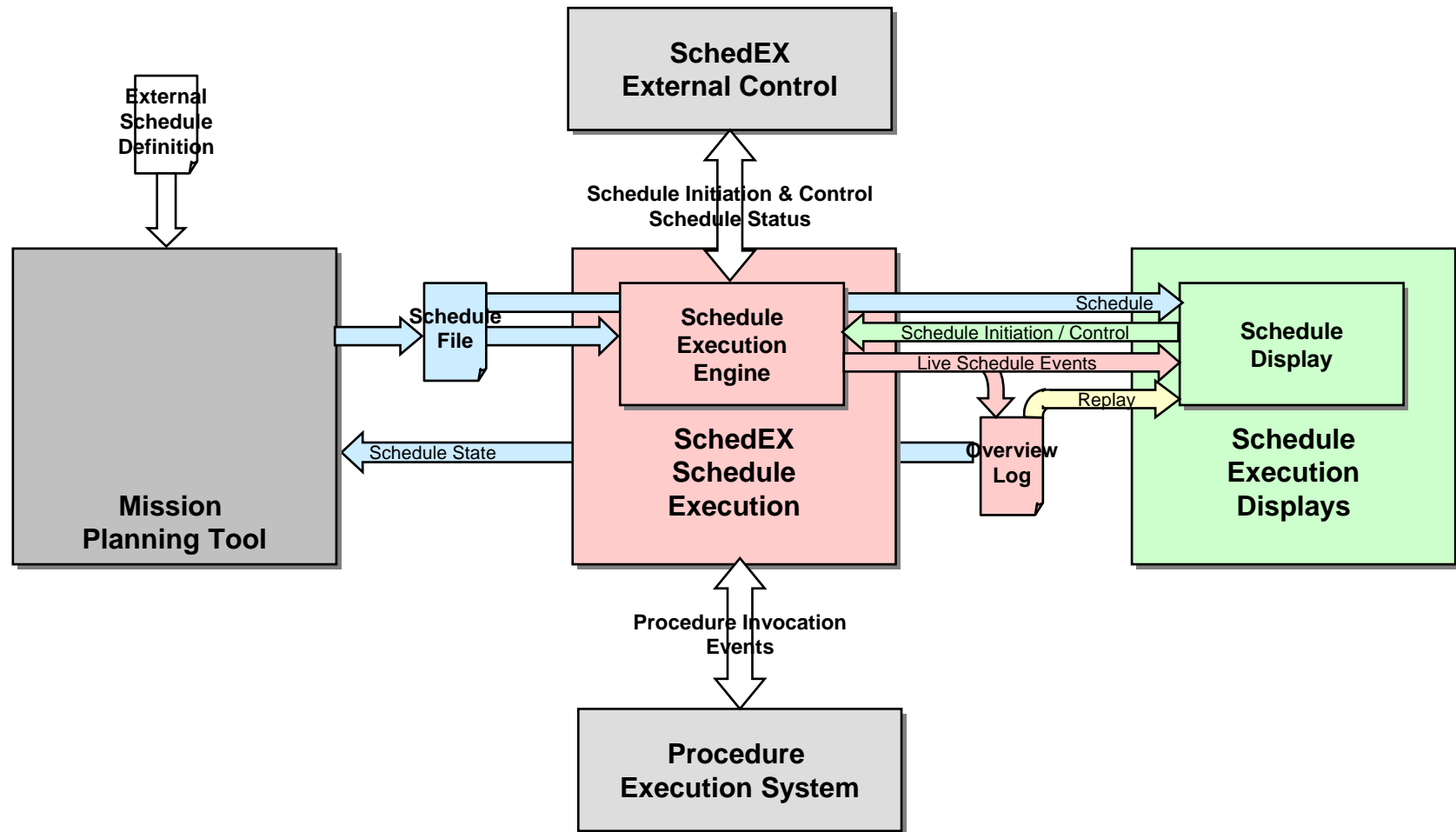


# Schedule Execution - SchedEX

- Executes the items in the Schedule generated from the Mission Planning tool
- Tasks can be Commands/Directives or Procedures
- Schedule Execution Server
  - ⇒ Provides a distributable engine to execute the currently loaded schedule
  - ⇒ Provides feedback to the execution client and mission planning
- Schedule Execution Client
  - ⇒ Real-Time update of the execution of the schedule
  - ⇒ Status of executed tasks indicated by colour
  - ⇒ Provides the same look-and-feel and the PLANEX Mission Planning MMI
- Java-based for portability



# SchedEX: Component Architecture



# SchedEX: Run Time Execution

The screenshot displays the SCPF Workbench interface for GAL SAT-4. The main window shows a task execution timeline from 16:00 to 23:30. Tasks are represented by colored bars: green for planned, red for conflicts, and yellow for other states. Conflict markers (CON 1, CON 2, CON 3) are placed above the timeline. Conflict types (CT) are shown below the timeline. The status panel on the right shows the following information:

Parameter	Value
TIME	2007.005.15.30.28
CHAIN	OPE
MODE	Master
USER	Stewart Hall
ROLE	Support
WKSTN	SCPF-WS-1
SERVER	SCPF-SV-P

The satellite list on the bottom right shows the following status for GAL SAT-4:

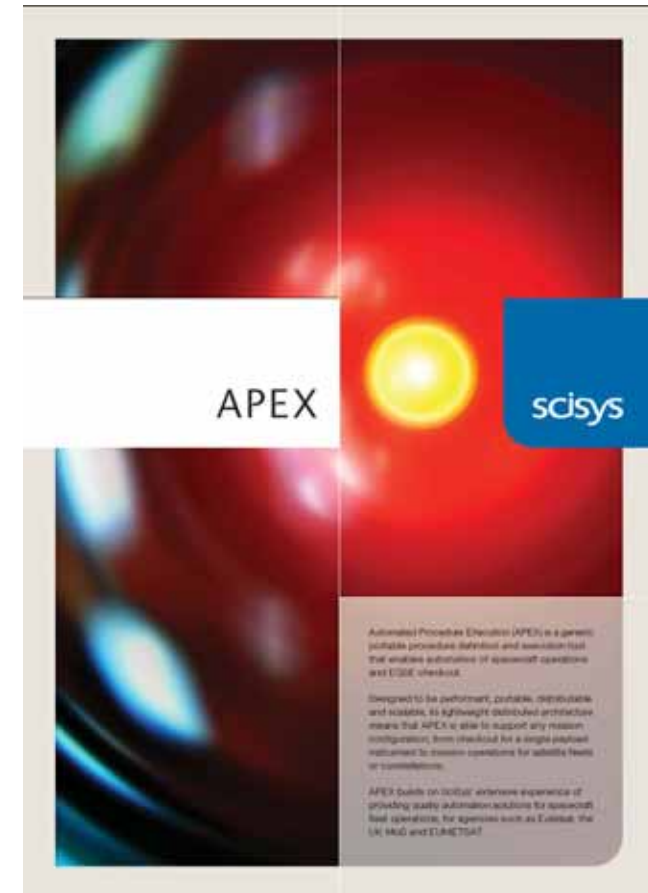
- GAL SAT-1(Planned)
- GAL SAT-2(Conflict)
- GAL SAT-3(Planned)
- GAL SAT-4(Planned)**
- GAL SAT-5(UnPlanned)
- GAL SAT-6(UnPlanned)
- GAL SAT-7(UnPlanned)
- GAL SAT-8(Planned)
- GAL SAT-9(Conflict)
- GAL SAT-10(Conflict)
- GAL SAT-11(Planned)
- GAL SAT-12(Planned)
- GAL SAT-13(UnPlanned)
- GAL SAT-14(Planned)

The console at the bottom shows the following operations:

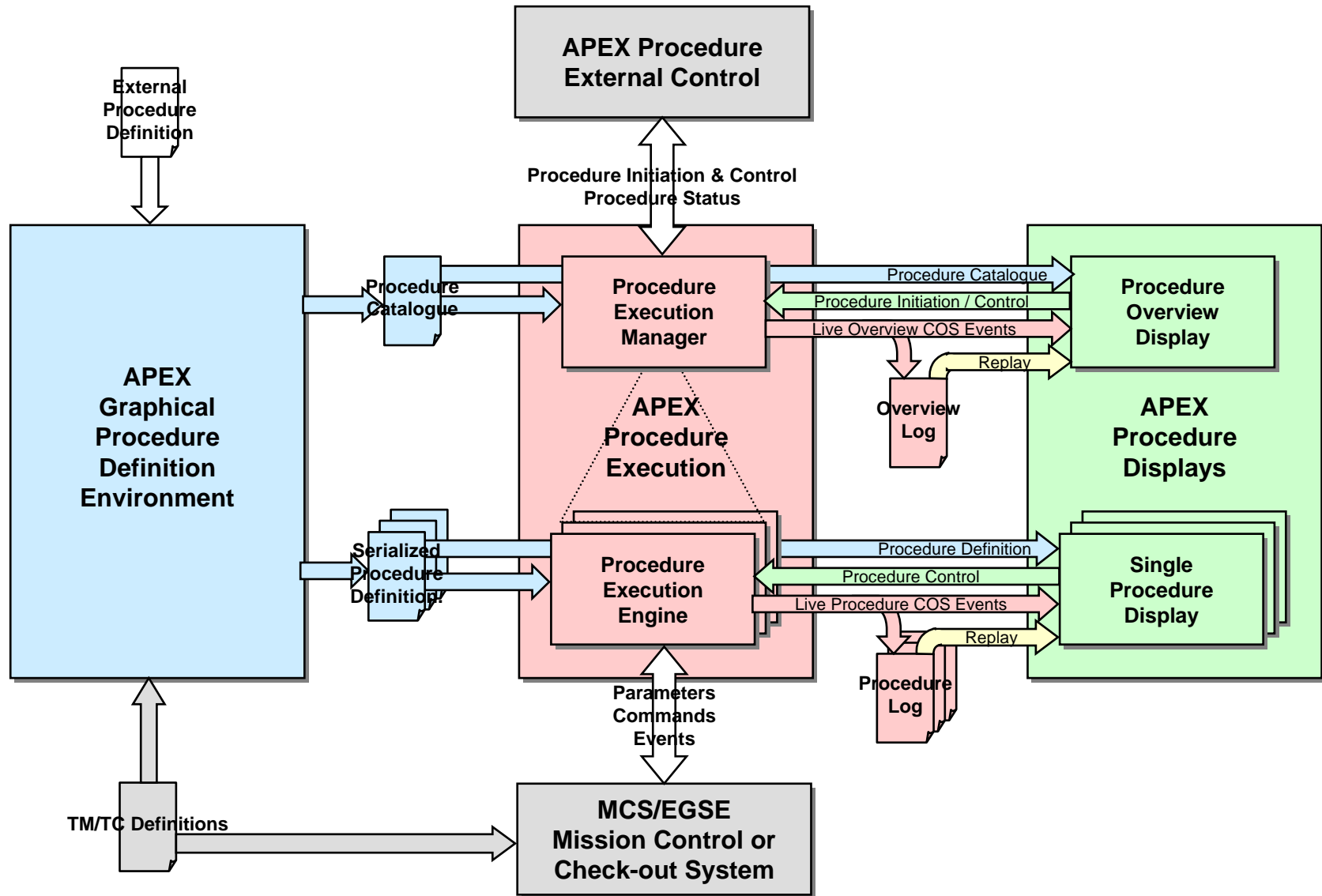
```
2007.005.13.27 All SCPF Servers Started
2007.005.13.27 SCPF Operator Logged on
```

# APEX: Automated Procedure Execution

- APEX: advanced, proven solution
  - ⇒ 3<sup>rd</sup> Generation System
  - ⇒ Robust, Scalable, Distributable
  - ⇒ High Performance
  - ⇒ Integrates into customer's systems
- Operational Procedure Model:
  - ⇒ Not just a Scripting Tool
  - ⇒ Open Service Interfaces
  - ⇒ Event Model supports Displays and History
  - ⇒ Graphical Visualisation Editor and Displays
- Java for Portability



# APEX: Component Architecture



# APEX: Graphical Procedure Editor

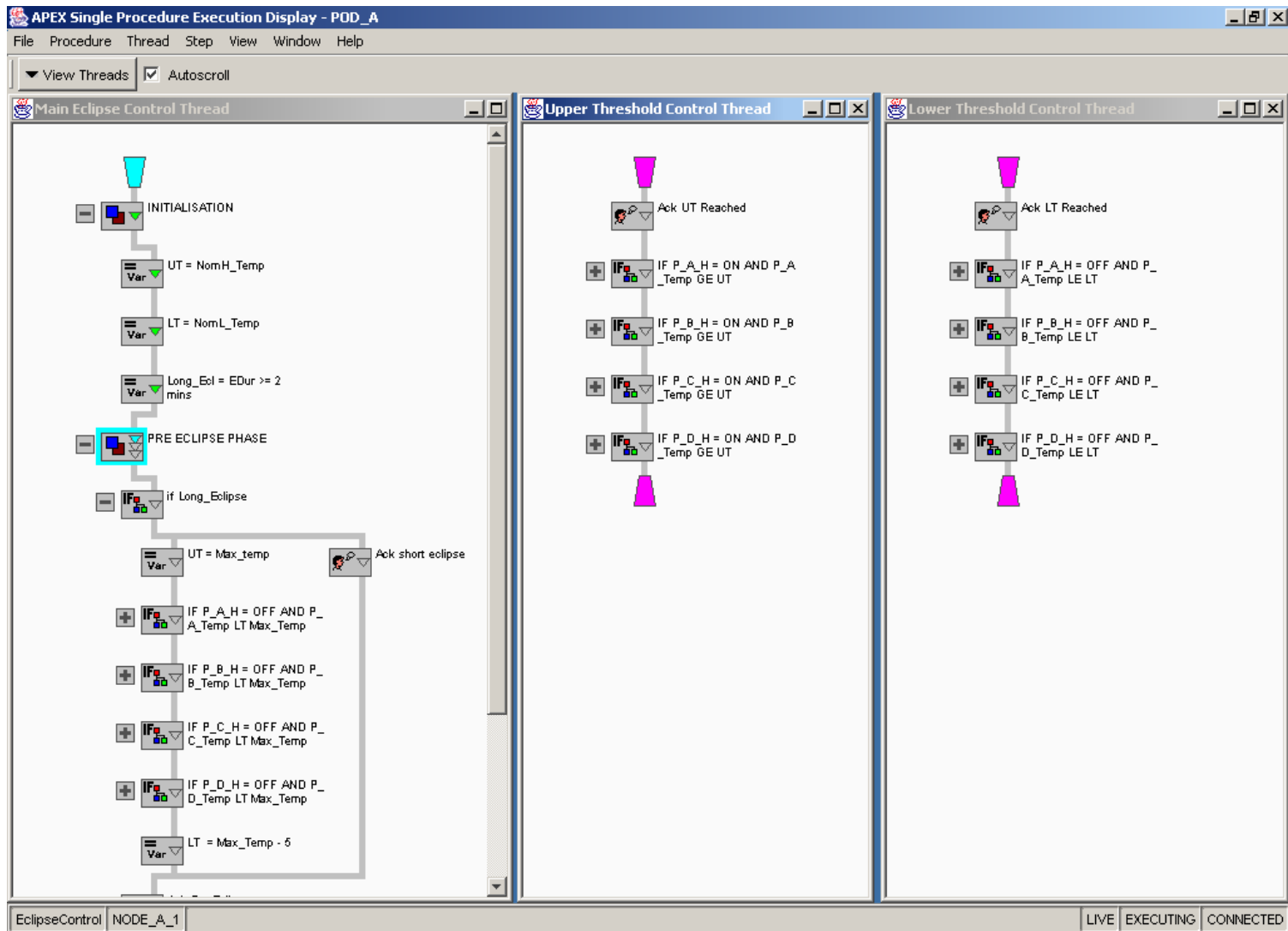
The screenshot displays the APEX Procedure Editor (Read Only) interface. The main window shows a flowchart for the procedure "SEVIRI Decontamination". The flowchart includes steps such as "P.8 - Call SN\_SV106 SEVIRI configuration from C1\* to C3\*", "P.9 - Confirm LCL12 OFF.", "P.10 - Was the SEVIRI Redundant Sunshield Decontamination HTR used?", "P.10.B1 - Confirm LCL33 OFF.", "P.10.B2 - Was redundant HTR & TM switched ON?", "P.10.B2.B1 - SN\_SV377: FCU HTR & TM OFF (R)", "P.10.B3 - Was LC31 switched ON?", "P.10.B3.B1 - 076P2C\_P: LC L31 SEV FCU R OFF", "P.11 - Call SN\_SV112 SEVIRI configuration from C3\* to C1\*", "P.12 - To scan: Edit next SN\_SYSS3 in schedule (edit K3 and END\_M=NOMINAL)", and "P.13 - MRF Restoration".

The right-hand pane shows the configuration for the selected step "P.10.B3.B1, 076P2C\_P: LCL31 SEV FCU R OFF, Send Command Step". The configuration includes:

- Title: 076P2C\_P: LCL31 SEV FCU R OFF
- Description: LCL31 SEV FCU R OFF
- Label: (empty)
- Specific:
  - Command Domain: MSG1
  - Command Identifier: 076P2C\_P
  - Description: LCL31 SEV FCU R OFF
- Arguments: (empty)
- Flags:
  - Critical:
  - Authorised:
  - Disable PTV:
  - Disable CEV:
  - GS Completion:
  - GS Progress:
  - GS Start:
  - GS Acceptance:
  - SC Execution:
  - SC Acceptance:
- Execution Time: (empty)
- PTV Expression: PDUALUX01.raw() == 1;
- PEV Expression: (empty)
- Result Var Identifier: LCL31



# APEX: Run-Time Display



# Eumetsat MSG – Automation in Practice

- Central E...  
complex  
Operatio

- ⇒ Multi
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*CCSDS SM&C  
Concepts now being  
applied to the  
Meteosat Third  
Generation Ground  
Segment Architecture  
Definition*

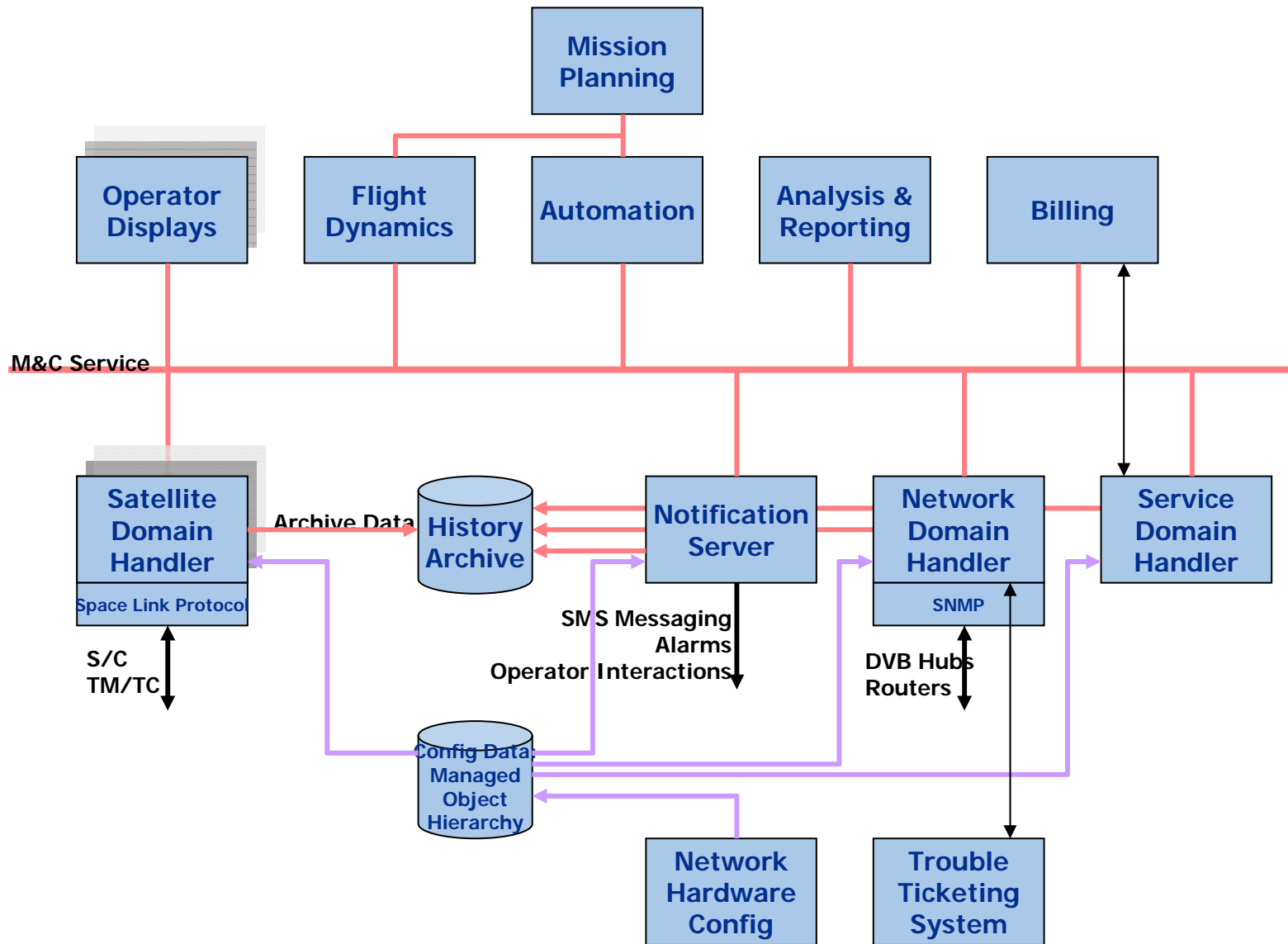
Monitoring  
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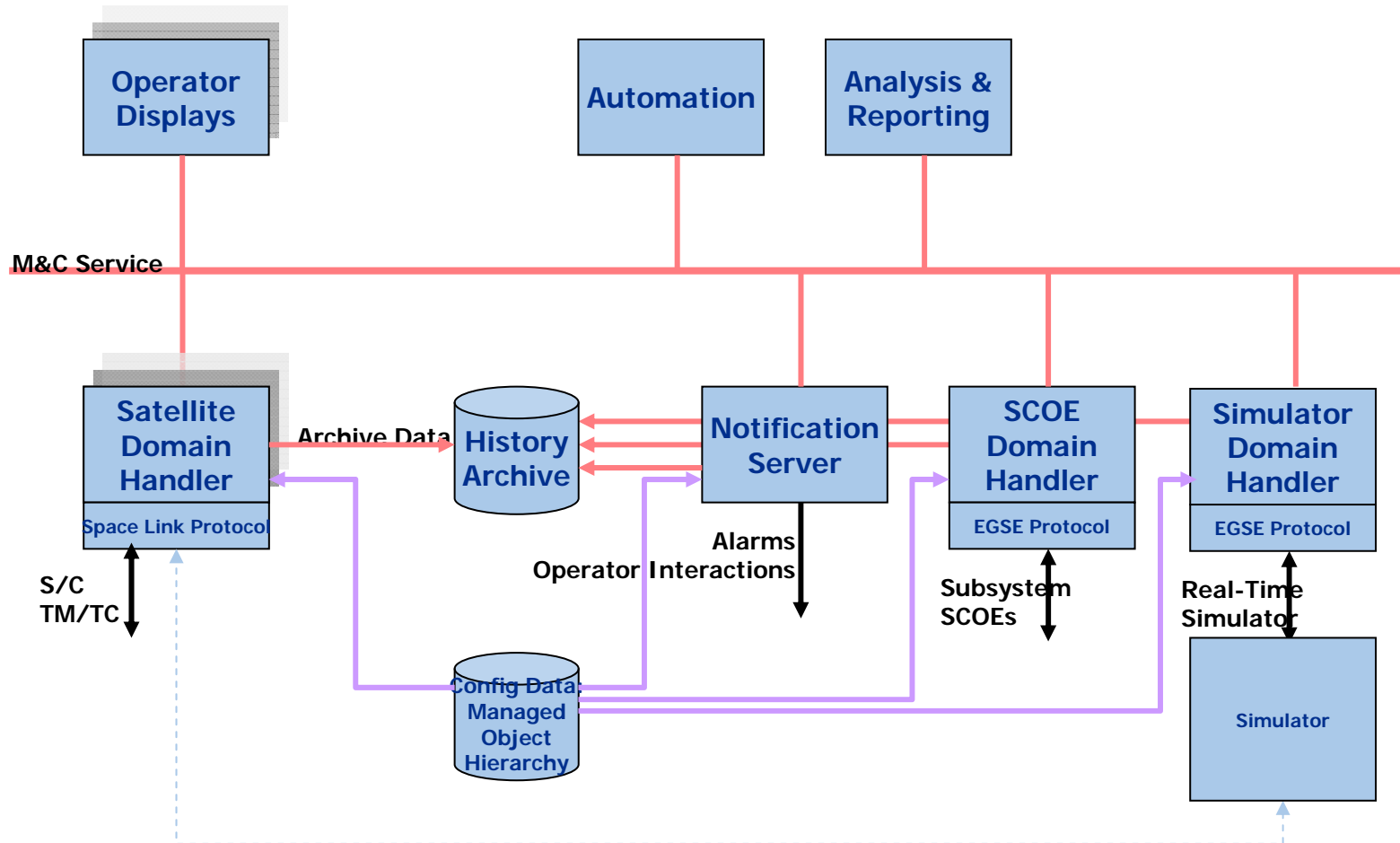
- ⇒ CF equipment
- ⇒ PDS equipment in multiple environments and sites



# Integrated SOC/POC/NOC Concept



# Application to EGSE Systems



# Summary

- CCSDS SM&C Standards provide an open basis for future spacecraft ground segments
  - ⇒ Currently Green Book for SM&C services under review
  - ⇒ There is now strong interest from BNSC, CNES, ESA, & NASA
- Coherent integration of Mission Operations Components e.g. Automation
- Supports *coherent* archiving of ALL mission operations data (not just TM/TC)
- Applicable to all mission classes
- Can be applied to EGSE and M&C of the entire ground segment (e.g. payload and service segments)



# Questions?

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