An operations preparation ecosystem

Ground System Architectures Workshop 2021

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Ground System Architectures Workshop - GSAW 2021

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An operations preparation ecosystem

EGOS-CC’s OPEN preparation environment and the related applications for managing the tailoring data of the next generation of monitoring and control systems used at ESA

Common Ground Segment Monitoring and Control

The current generation of heterogeneous control systems used at the European Space Operation Centre (ESOC) for Mission Operations and Ground Station Monitoring and Control are facing obsolescence

ESOC is implementing a project (**EGOS-CC**) with the aim of replacing the current ESA Ground Segment Monitoring and Control systems by a new Monitoring and control infrastructure

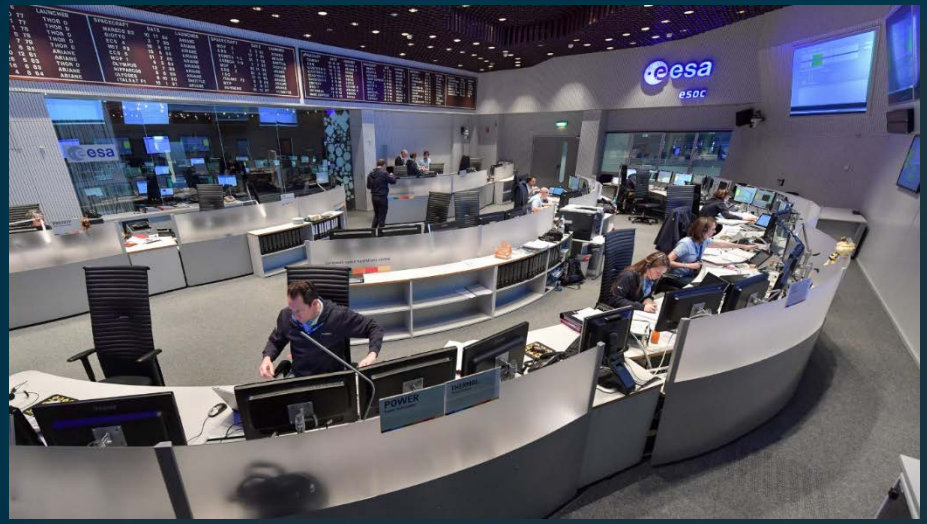
Approach

- Building upon the European Ground System - Common Core (**EGS-CC**), an ESA-led European initiative developing a common European Monitoring & Control infrastructure
- Ambitious objectives – aiming for a generic system, tailorable to support multiple use cases

High-level Introduction

European Space Operation Centre (ESOC)

- Monitoring and Control of Spacecraft and Ground Stations



ESTRACK

ESA's tracking station network

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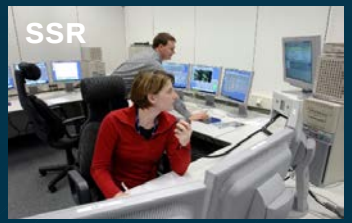

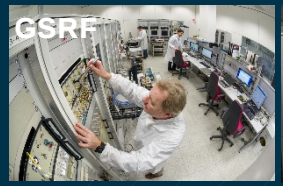

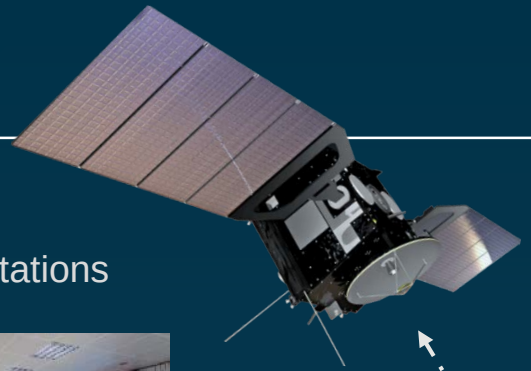

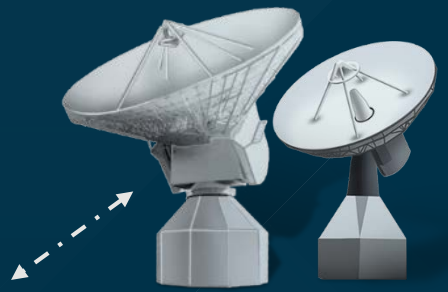

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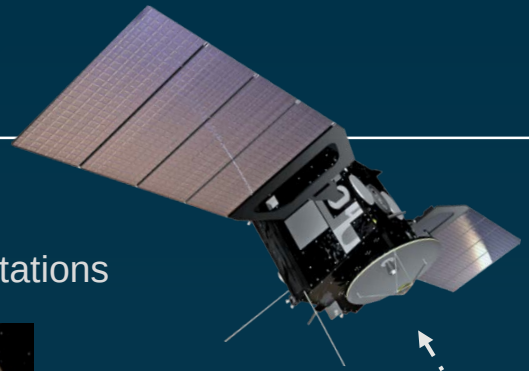

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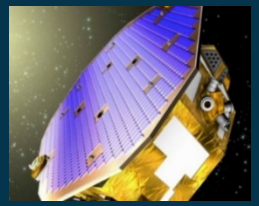




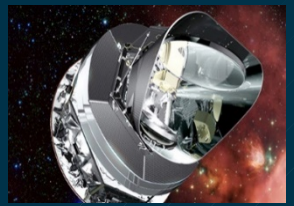

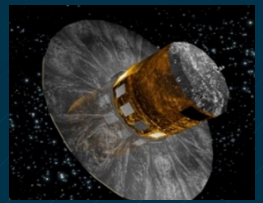


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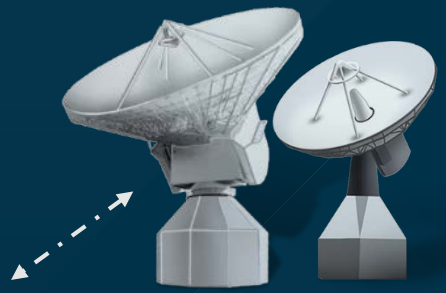

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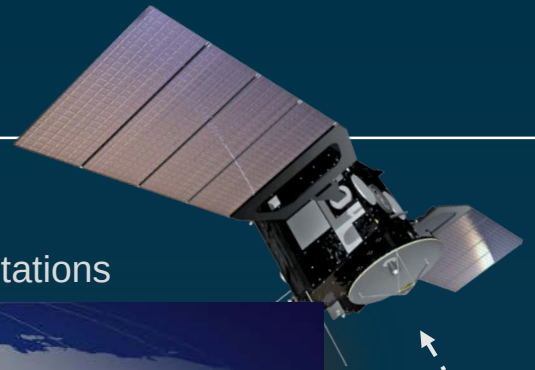

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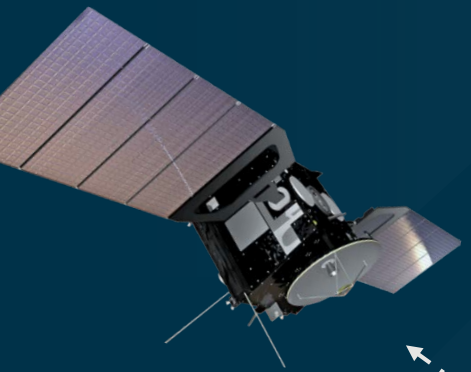
ESA's tracking station network

High-level Introduction

Monitoring and Control Systems

- Mission Control System (MCS)
- Ground Station Monitoring and Control (GSMC)



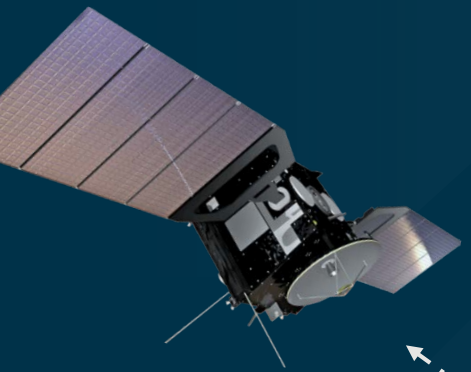
Mission Control System (MCS)

Ground Station Monitoring and Control (GSMC)

High-level Introduction

EGOS-CC – ESA/ESOC project for the adoption of EGS-CC

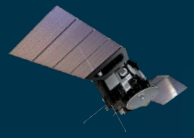
EGS-CC – European Ground System - Common Core



Mission Control System (MCS-CC)

Ground Station Monitoring and Control (GSMC-CC)

EGOS-CC High-level Architecture



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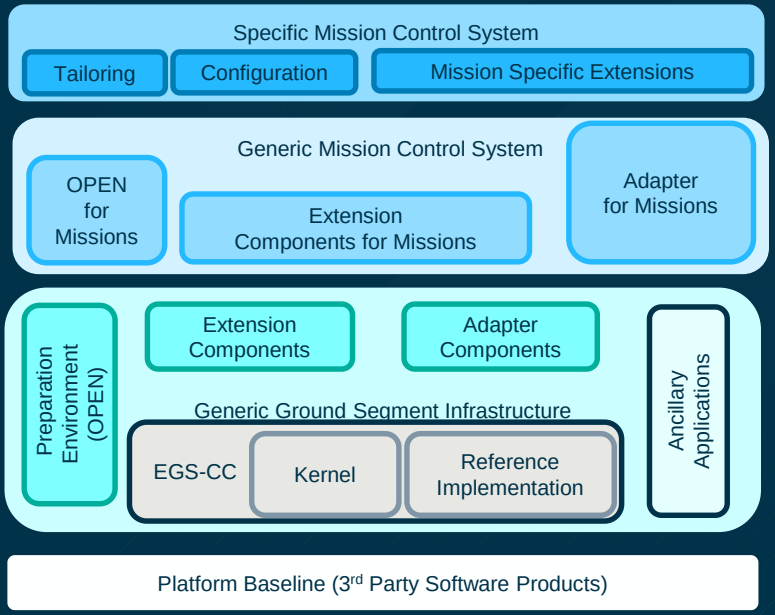

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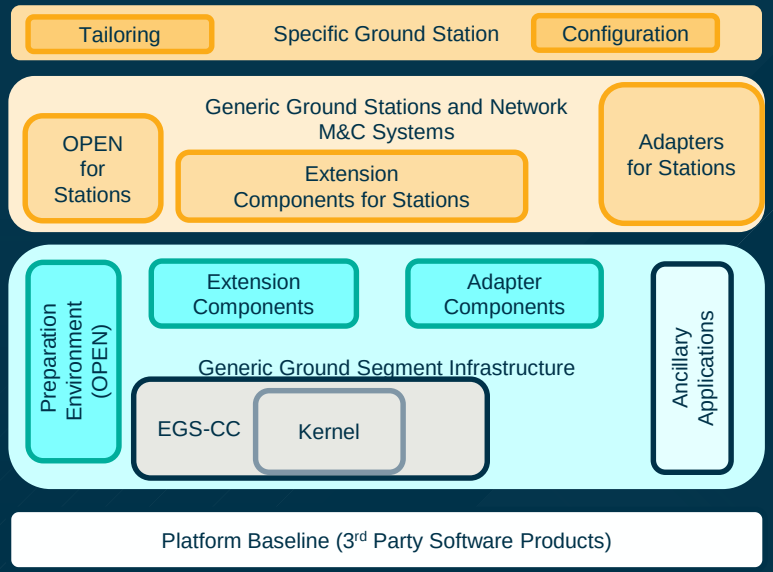

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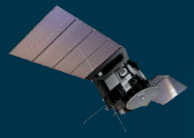

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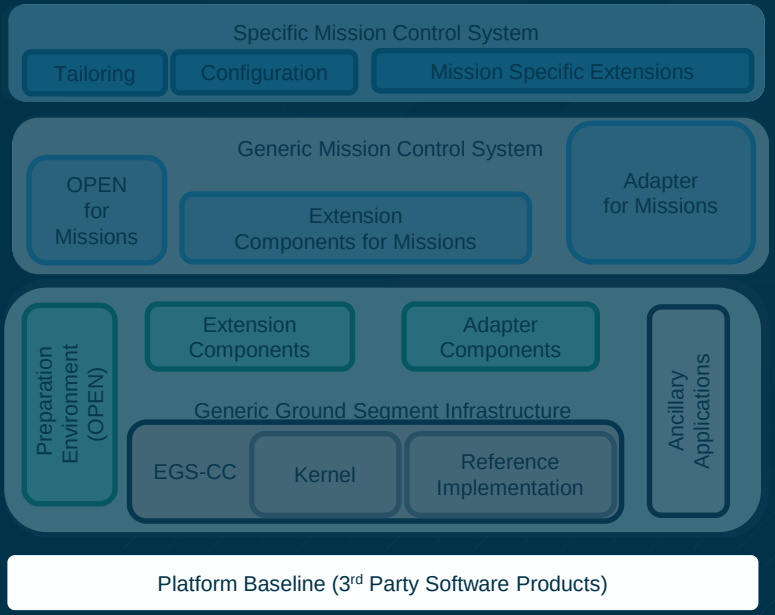
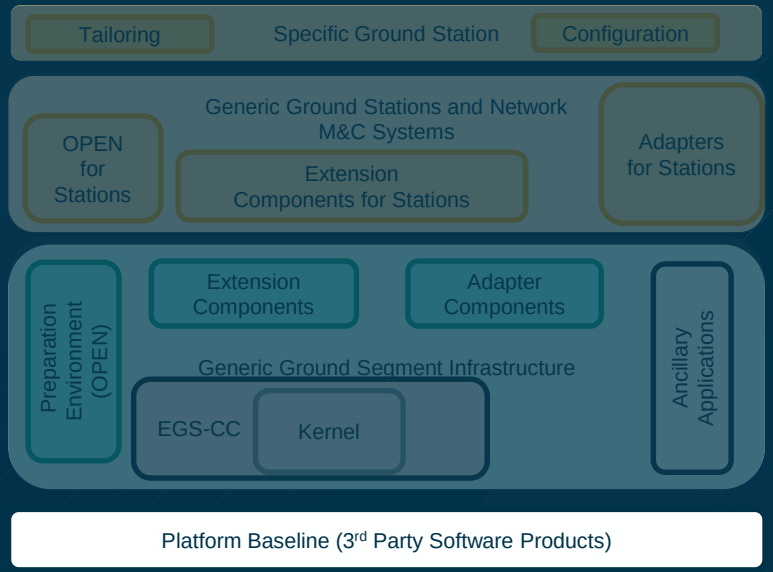


Platform Baseline (3rd Party Software Products)

Ground Station Monitoring and Control (GSMC)



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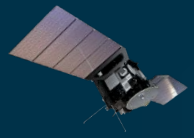

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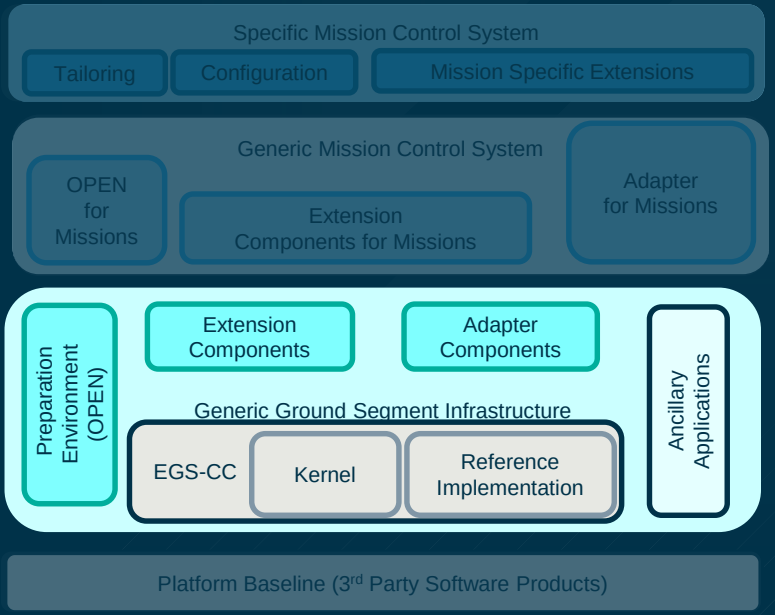

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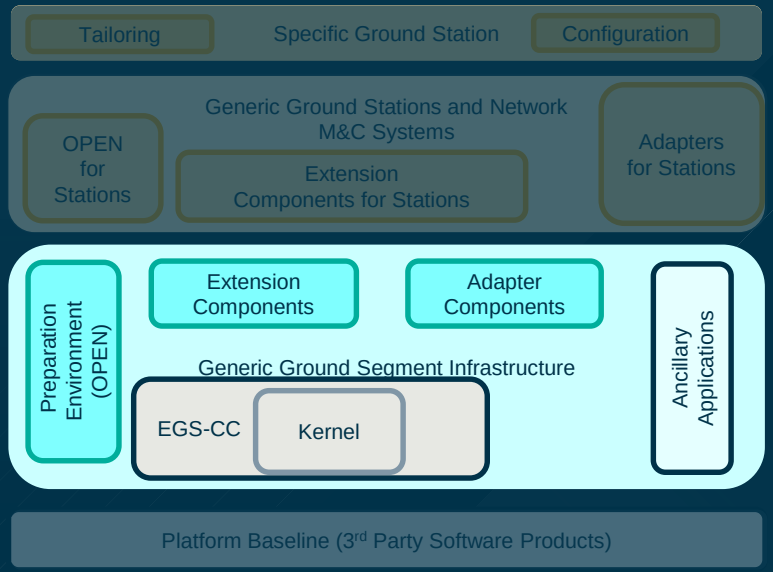

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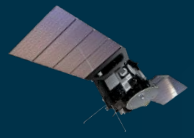

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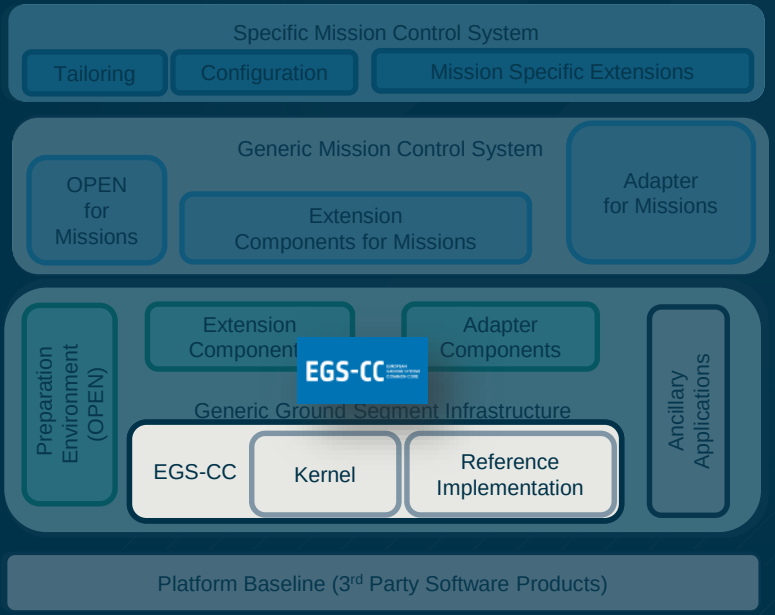

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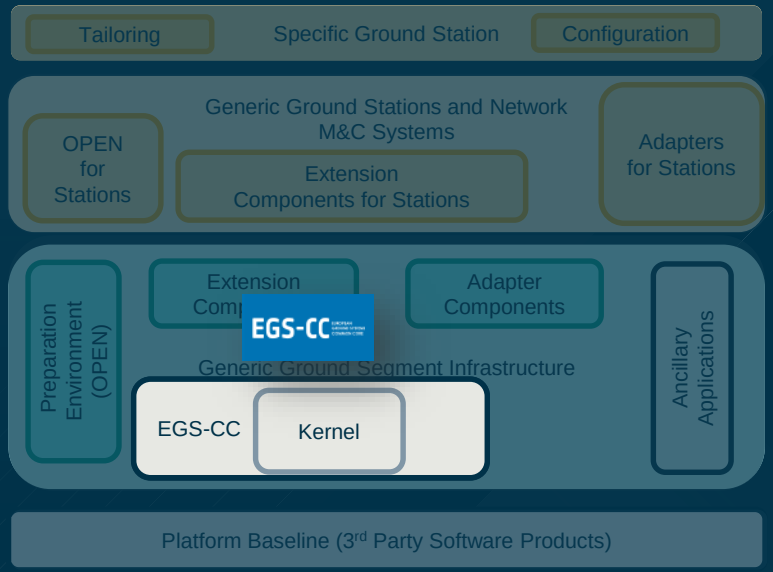

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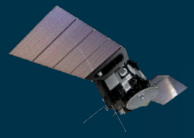

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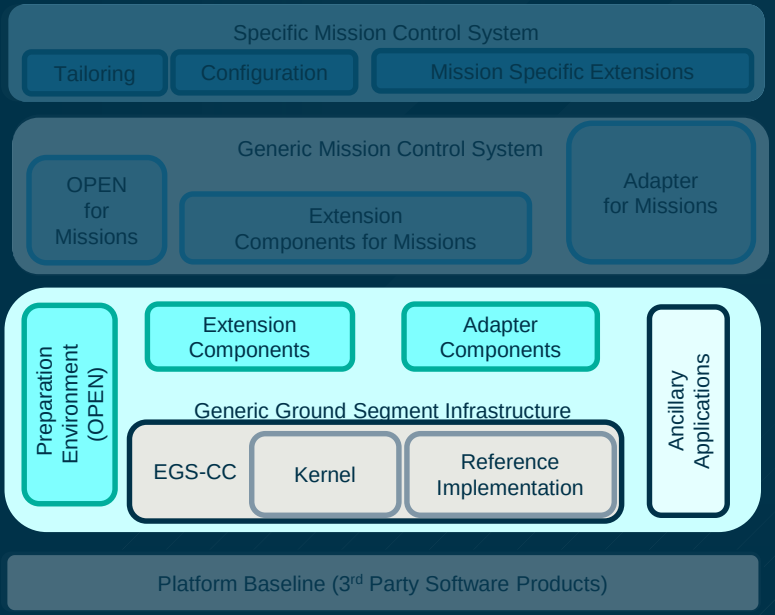

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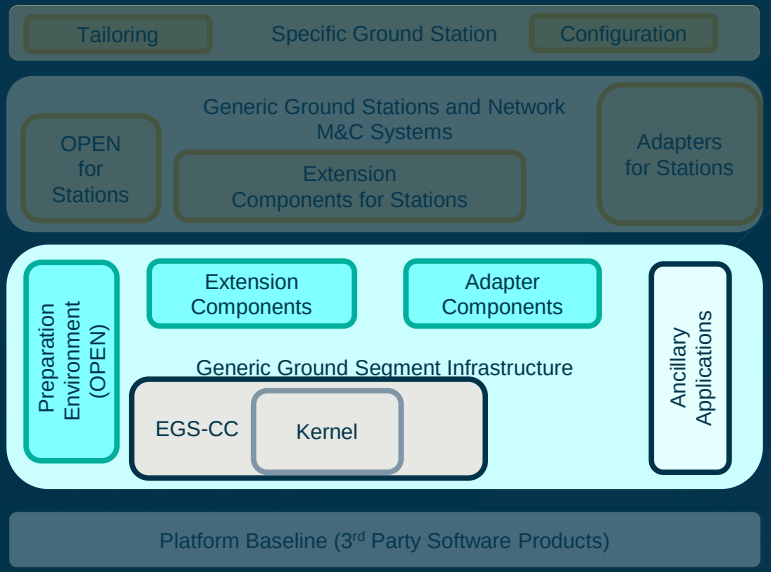

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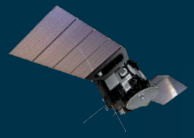

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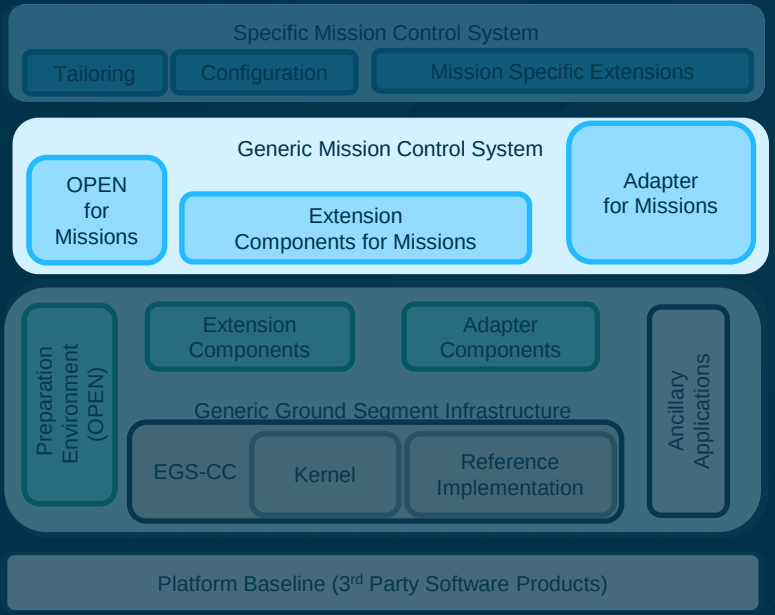

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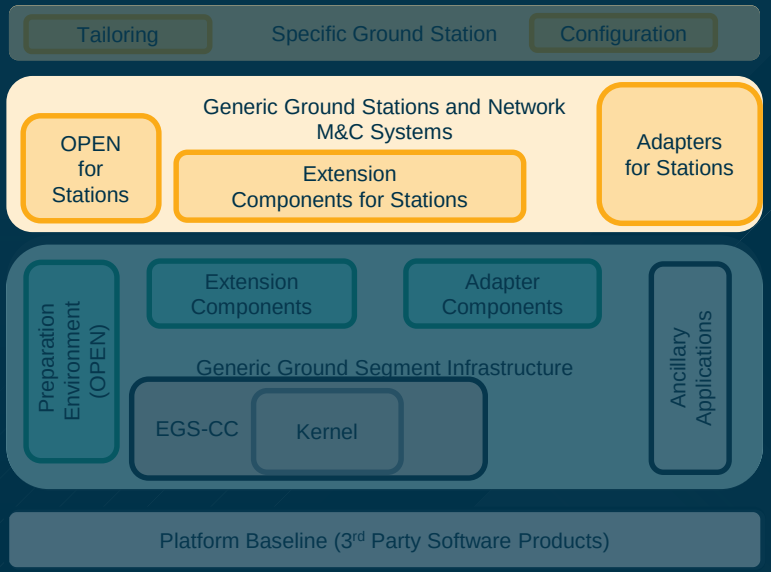

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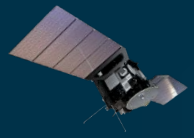

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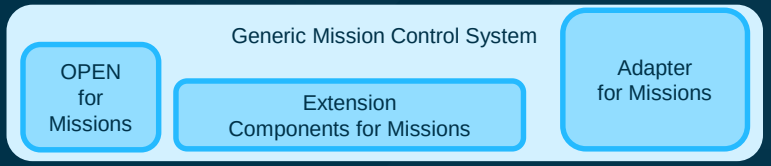

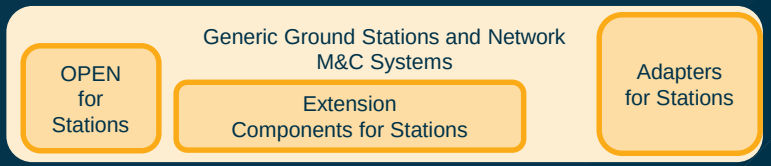

In this layer, e.g.

- User Interface Extensions (UIF)
- On-board Software Management (OBS)
- File based Operations (FBO)
- Telemetry File Ingestion (TFI)
- Ground Station M&C Adapter
- Flight Dynamics Adapter
- Alert System REALS Adapter
- Command Request Management (CR)
- Long Term Archive Management (LTA)
- ..

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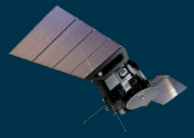

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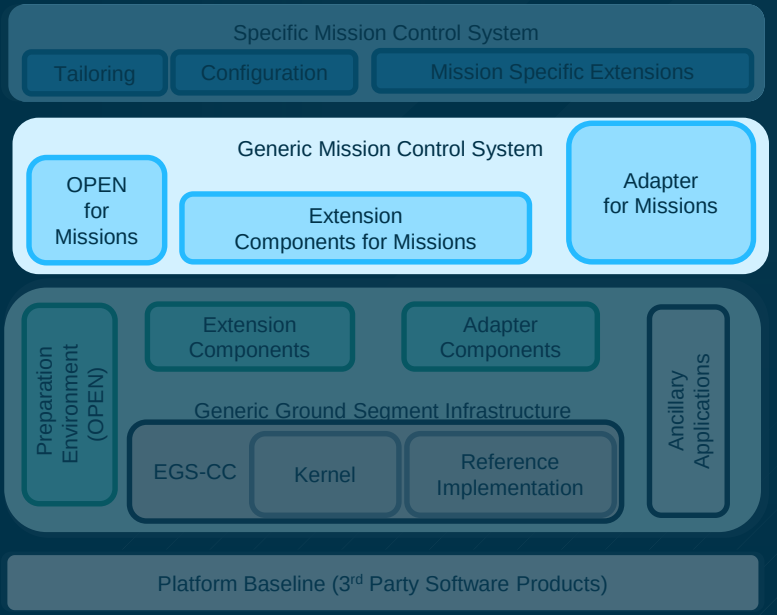

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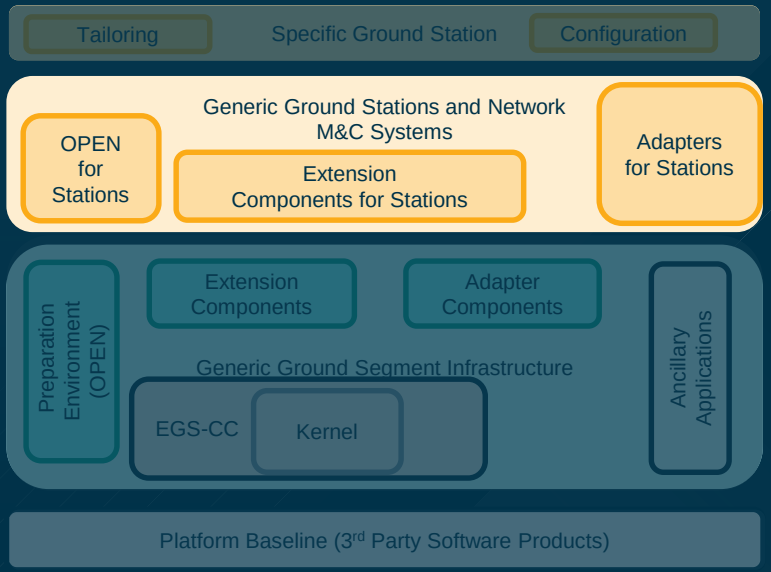

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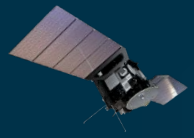

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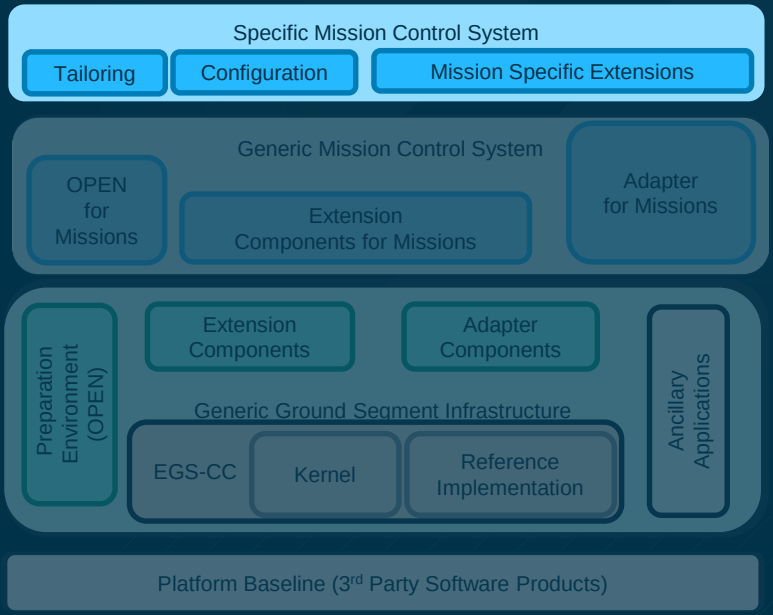

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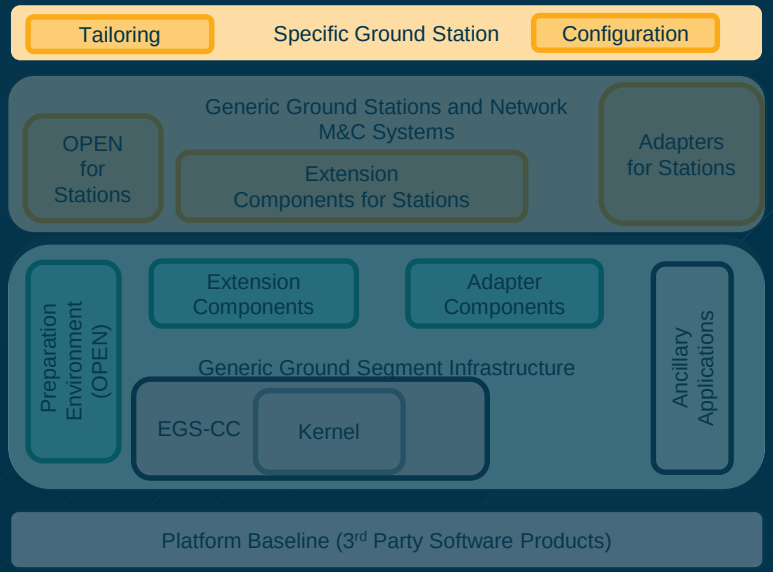

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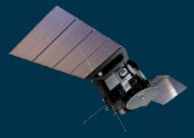

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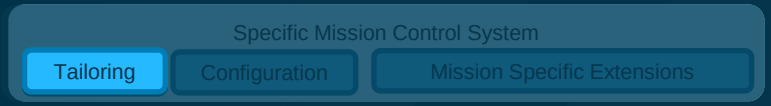
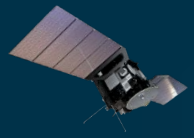


Ground Station Monitoring and Control (GSMC)

"Tailoring Data" covers all operator defined data consumed by the ground data M&C systems such as

- Monitoring and Control models of the controlled system
  - Data structures exchanged with the controlled system (e.g. TM/TC packets)
- Operations Procedures (manual, automated, on-board)
- User Defined Displays (alphanumeric, scrolling, matrix, plots, mimics)
- Timelines, Schedule templates, Simulator scripts
- User configurations, …

EGOS-CC High-level Architecture



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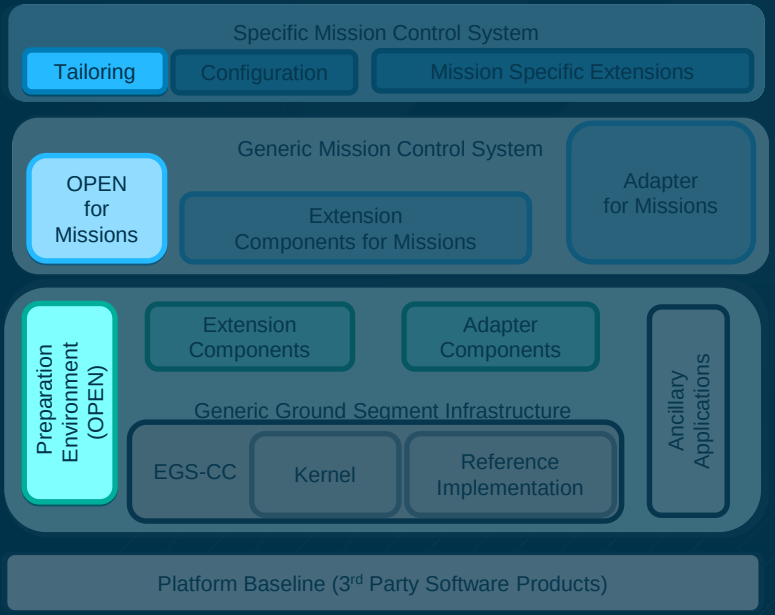

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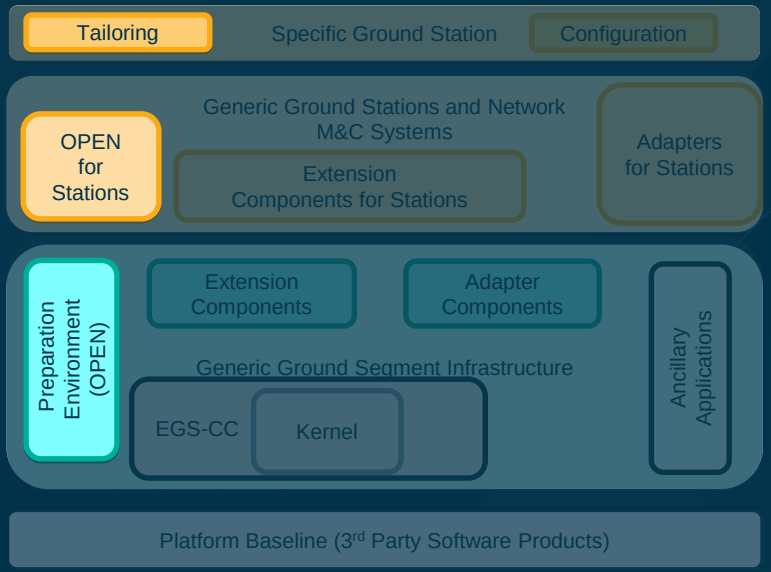
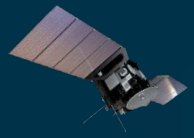


Tailoring Data Management for EGS-CC



Mission Control System (MCS)

Tailoring

OPEN for Missions

Preparation Environment (OPEN)

Ground Station Monitoring and Control (GSMC)

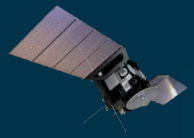
Tailoring

OPEN for Stations

Preparation Environment (OPEN)

New components for the Management of the Tailoring Data

Tailoring Data Management for EGS-CC



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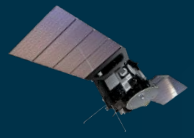


Missions
Tailoring Data

Ground Stations
Tailoring Data

OPEN-M
Preparation
Environment for
Missions

OPEN-S
Preparation
Environment for
Ground Stations

open

Preparation
Environment
Framework

New components for the Management of the Tailoring Data

High-level Simplified Overview

Tailoring Data Management for EGS-CC

Preparation Environments for
Management of EGS-CC Tailoring Data

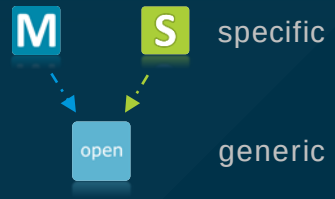
EGS-CC Based Runtime
Monitoring and Control Systems

- Provision of streamlined, consistent, unified preparation environments to manage operations data required to tailor/operate the ground data systems
- Targeted towards EGS-CC systems, models and data
- Provides harmonised and coherent solution for the preparation of all monitoring and control tailoring data at ESOC

OPEN Preparation Environment Framework

- **OPEN Framework is the foundation of software applications and services which are provided to end users, such as AIT engineers, operators and simulation teams.**

Main features



- Software framework (generic functionalities which can be selectively changed or expended)
- Model based (Automated generation of generic editors based on the model)
- Basic and generic user functions supporting the dedicated preparation environments
  - Version Control, Access control (Distributed using Simplified Tasks System)
  - Consistency checking (+ preparation/debugging of tailoring model checks)
  - Generic instance editors (User customizable “Form editors”) and multi instances editors (“Table editors”)
  - Import and Export in EGC-CC native data exchange format
  - Export to EGOS-CC M&C Systems (using EGS-CC data formats + additional OPEN metadata)
  - Scripting environment (Execution/Debugging of groovy scripts with API for framework services and CDM data modifications, Possibility for end-users to create additional UIs)
  - Data compare and Two or Three ways merging (CDM object model comparison - Custom EMF Compare UI)
  - Visualisation of Tailoring Model (navigate the EGS-CC CDM: object types, type hierarchies and properties)
  - Dedicated editors for Expressions, Groovy scripts, EAPL procedures, EUD User Defined Displays (Matrix, ANDs, etc..)
  - ..

Specific Functionalities

OPEN-M
Preparation
Environment
for Missions

- **OPEN-M includes EGS-CC tailoring data editors and browsers to support the needs of the Mission Control Teams at ESOC**

- **Main Functionalities**
- All functionalities of the OPEN framework
  +
- Dedicated configuration for Mission Control Teams
- Dedicated user documentation
- Import of SCOS-2000 MIB format (conversion from SCOS-2000 to EGS-CC Tailoring Model)
- Export to legacy systems in MIB format (sub-set only)
- ..

OPEN-S
Preparation
Environment for
Ground Stations

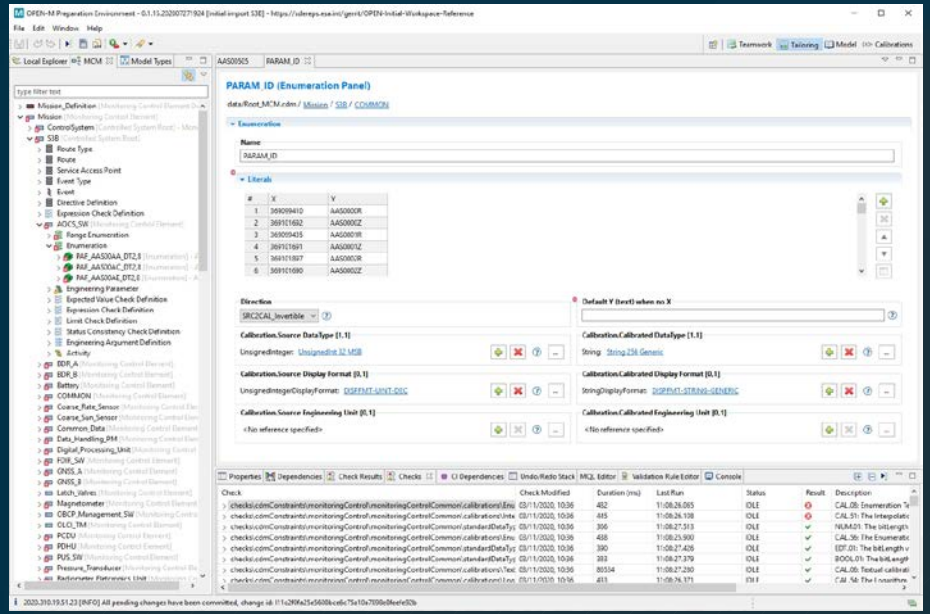
- **OPEN-S includes EGS-CC tailoring data editors and browsers to support the needs of the Ground Stations Tailoring Team at ESOC**

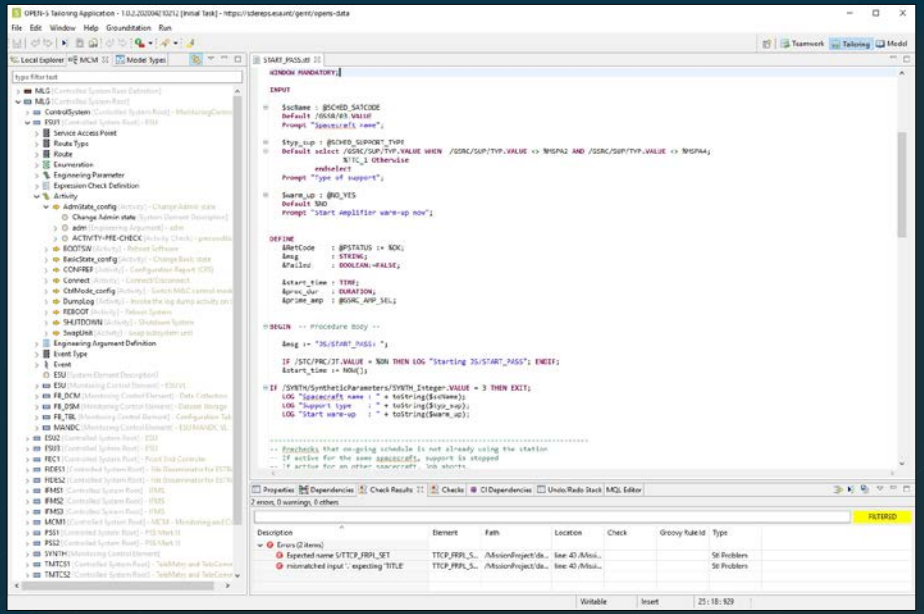
- **Main Functionalities**
- All functionalities of the OPEN framework
  +
- Dedicated configuration for Ground Stations Teams
- Station Tailoring Language Procedure Editor
- Dedicated user documentation
- Import of Ground Stations MIB format (conversion to EGS-CC Tailoring Model and Ground Stations Extensions)
- ..

Specific Functionalities

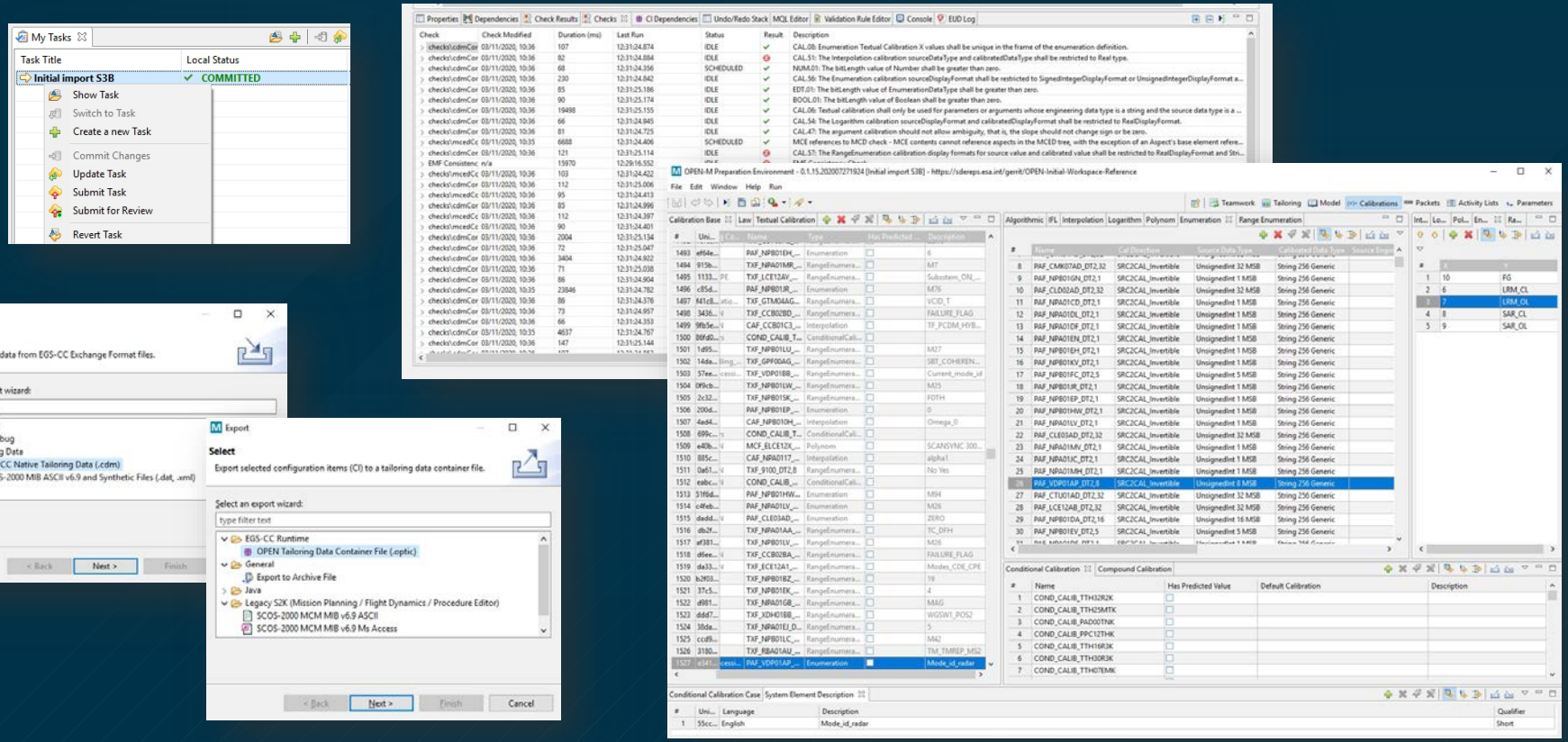
OPEN-M
Preparation
Environment
for Missions

OPEN-S
Preparation
Environment for
Ground Stations

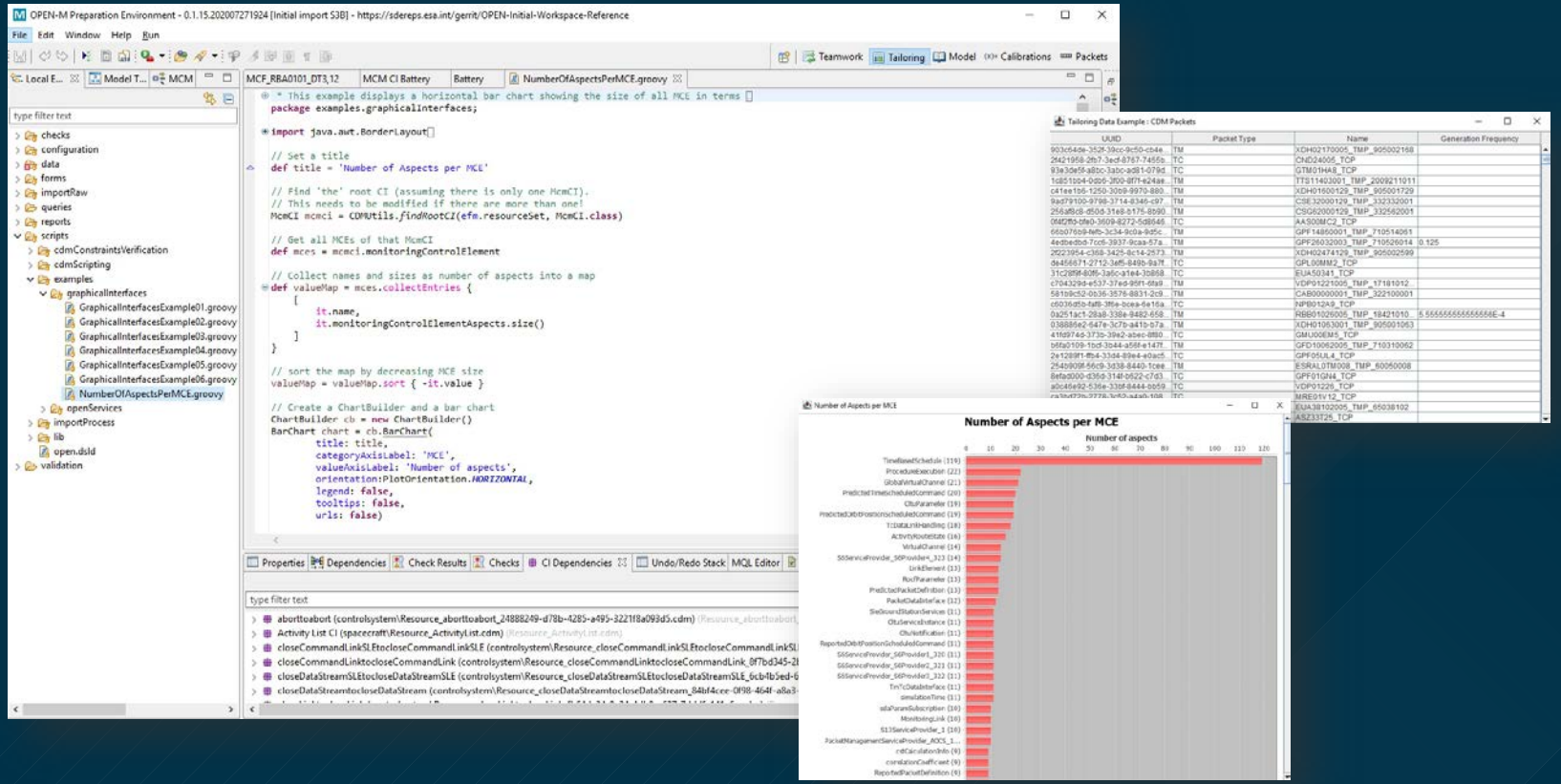




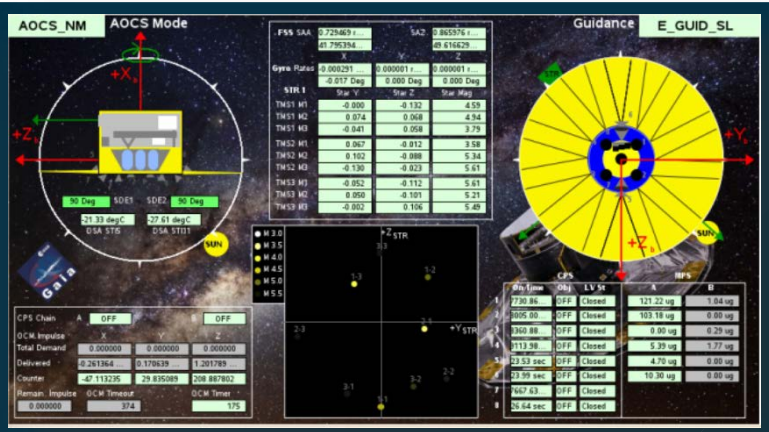
OPEN Preparation Environment Framework

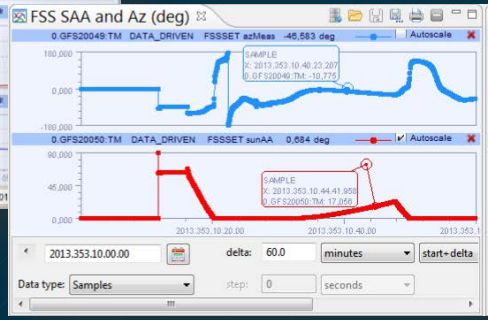


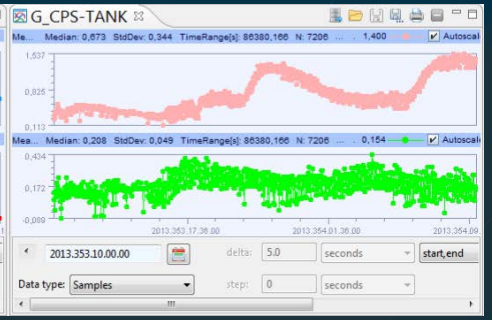
OPEN Preparation Environment Framework



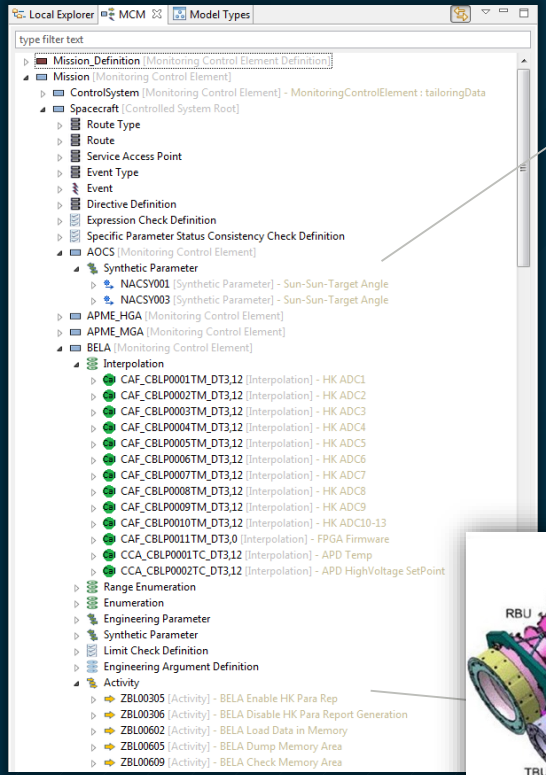
OPEN Framework User Defined Display Editors

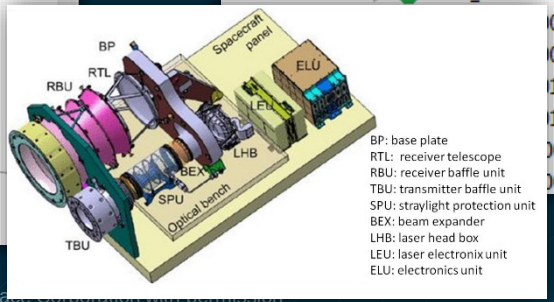


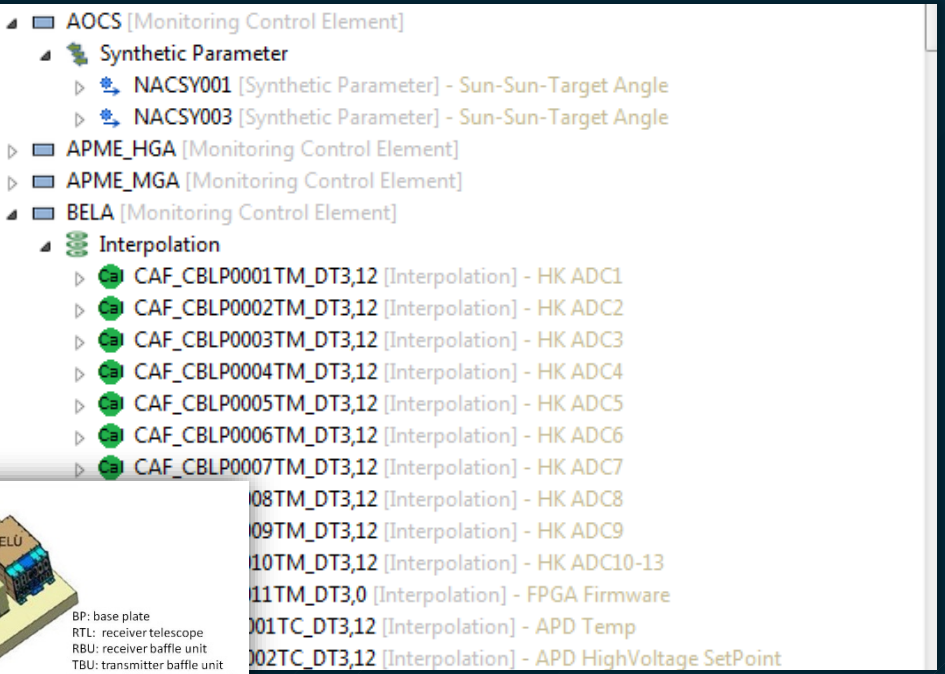




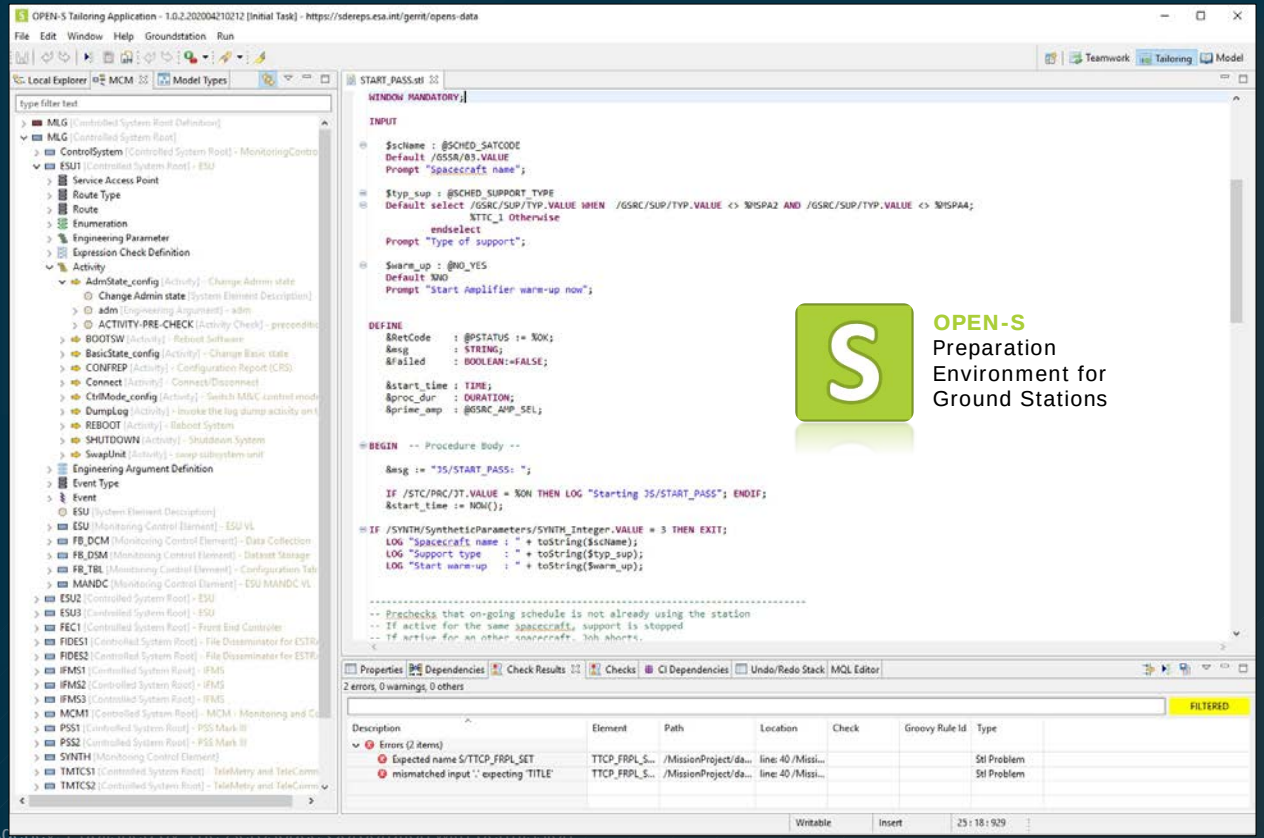
Example View : Monitoring Control Model



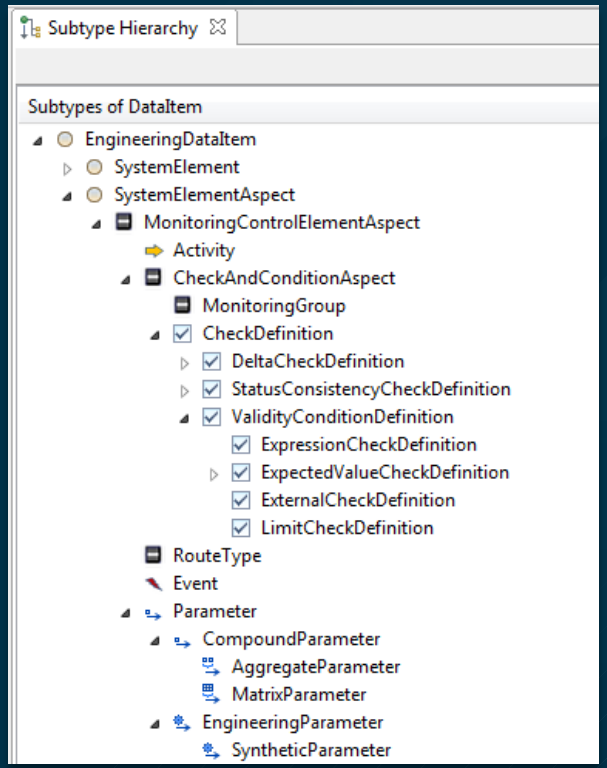


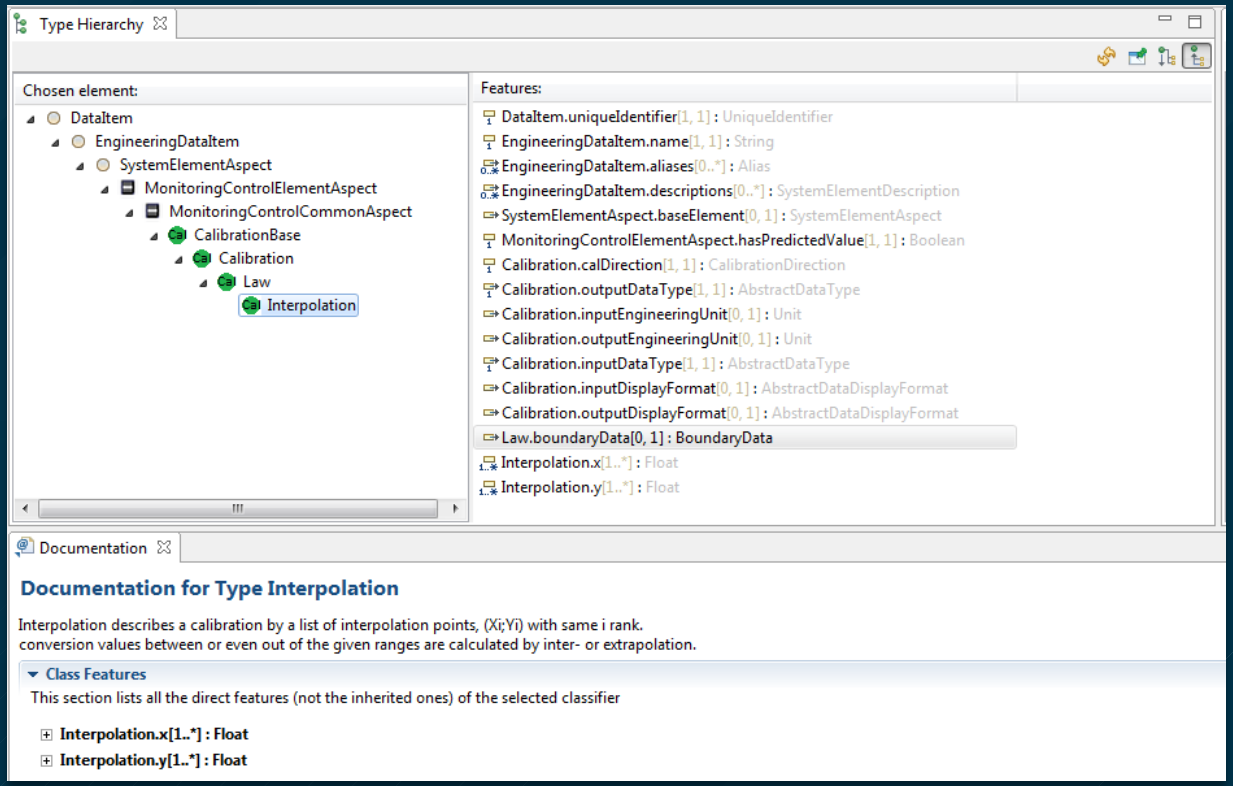


Example Editor : Automation Procedure



Example View : Model Visualisation



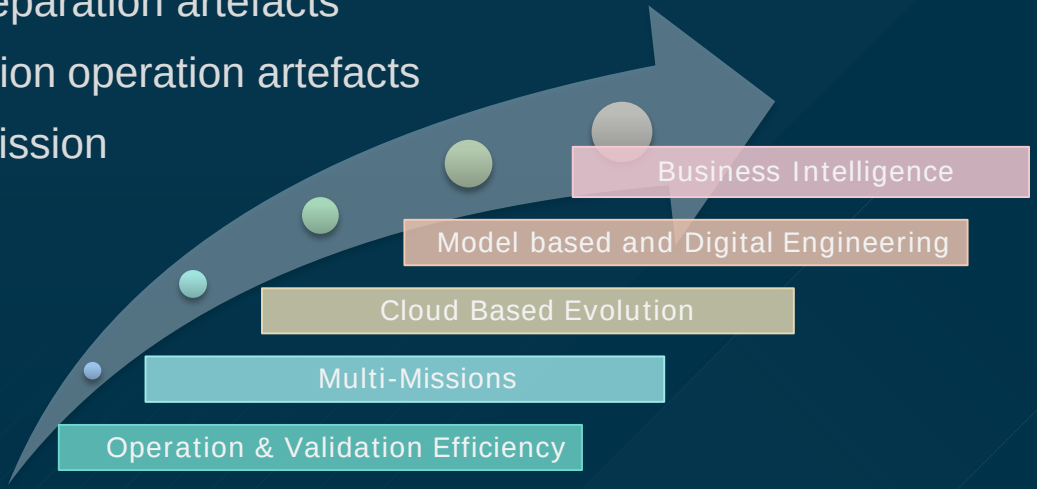


Expansion of the applications and further extensions

- The family is expanding further through new applications and extensions
- e.g. OPEN-D supports the management of the EGOS-CC system configuration files consistently with the tailoring model
- Foundation for an OPEN Multi-missions/Multi-systems Management
- OPEN-M Flight Control & Automation Procedures Management
- OPEN-M Timelines Management
- OPEN-M CCSDS MO services importer
- OPEN-M Extension for SIMULUS-NG

Perspectives of the OPEN environments

- Integration with Model Based Engineering Hub, Digital Ground Segment Engineering and Business Intelligence Platforms
- Improved operations efficiency of the ground segment (both missions and ground stations)
- Continuous Integration of operations preparation artefacts
- Support of automated validation of mission operation artefacts
- Enable coherent and innovative multi-mission integrated cloud based approach
- Integration with further operators tools and platforms



OPEN Environments

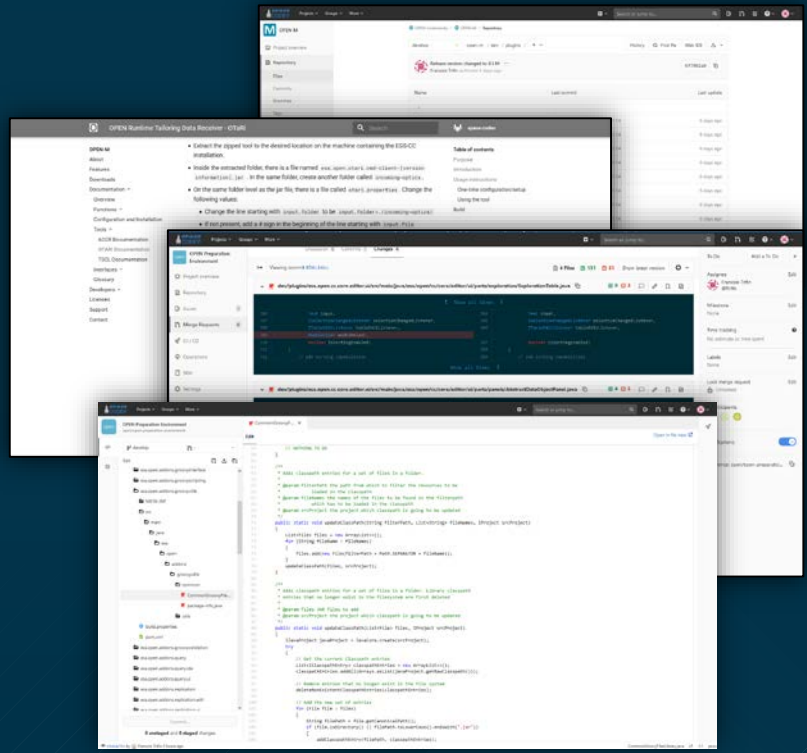
OPEN to proprietary extensions

- OPEN is technologically designed to be an extensible platform federating various extensions which can originate from several sources in terms of funding and organisation
- The licensing scheme adopted for the OPEN framework and OPEN-M are designed for collaborative development under the ESA Community Software License
- Proprietary extensions are intended as part of the OPEN-based applications

https://open.space-codev.org

- www.space-codev.org is a collaboration platform of the European Space community
  - Supported by the European Space Agency
  - Provides a collaborative software development environment
  - Projects available under the ESA Community Software License

- OPEN and OPEN-M Community Projects
  - Software Source code
  - Technical Documentation
  - Software Development Platform (Gitlab)



Take away

- The European Space Agency has developed an harmonised digital ecosystem of Ground and Space Monitoring and Control Preparation applications
  - ESA's tracking station network (ESTRACK) monitoring and control systems
  - ESA’s mission control systems
  - Relevant for the Assembly, Integration and Test (AIT) and satellite simulator M&C areas

- The OPEN ecosystem is expanding with new extensions and applications

- The European Space Agency fosters an OPEN community of users and contributors sharing the benefits generated by the common software applications

- The OPEN preparation environments are intended to evolve towards multi-missions cloud based solutions and data hubs increasing cohesion to further areas such as MBSE and Business Intelligence

Thanks for your attention!

Software, documentation and tutorials available at https://open.space-codev.org

Related presentations at GSAW 2021:

- *A truly generic platform for control systems*
- *From Mission-Centric towards Infrastructure-Centric Processes and Services*

We would like to acknowledge the excellent work of all the OPEN project team members