

# A truly generic platform for control systems

**Ground System Architectures Workshop 2021**

Klara Widegård, Mauro Pecchioli, Anthony Walsh – European Space Agency

Ground System Architectures Workshop - GSAW 2021

03/2021



# One control system to rule them all

The current generation of heterogeneous control systems used at ESOC for Mission Operations and Ground Station Monitoring and Control are facing obsolescence. **Can we replace them with a common solution?**

## Objective:

In 2016, we started a project (EGOS-CC) with the aim of replacing the current Ground Segment monitoring and control systems at ESOC/ESA by a new control system supporting multi-mission operations.

## Approach:

Building upon European Ground System - Common Core (EGS-CC), an ESA-led European initiative with early pre-studies starting already in 2011.

- Ambitious objectives – aiming for a generic system, tailorable to support multiple use cases

*5 years later, almost at the target line, what has become of the promises? Is the “one control system to rule them all” approach feasible?*

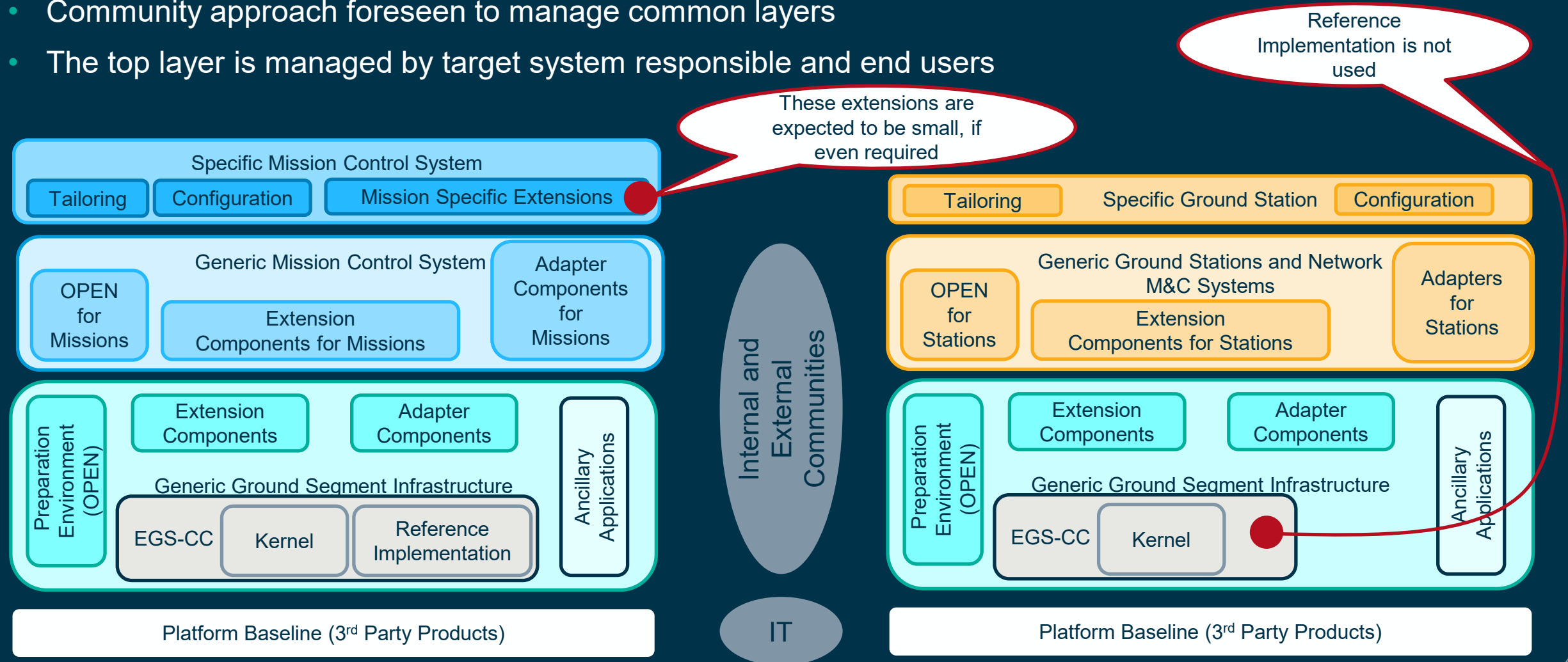
# A closer look at the EGOS-CC products

- **Mission Control System & Ground Station Monitoring and Control** runtime environment based on Common Core
  - ~70-80% of the features required for the runtime are covered by EGS-CC Kernel and Reference Implementation
  - Interface-based architecture supporting binary reuse
    - Functionality can be extended without changing EGS-CC itself
  - “EGS-CC” like components are developed as part of EGOS-CC to provide additional features
    - e.g. File-Based Operations and Ground Station Schedule Interface
  - Specific target applications can be compositioned from generic building blocks
- **Preparations Environment (OPEN)** to support the tailoring process
  - Management of the Conceptual Data Model used for tailoring
    - Model is separating generic monitoring and control aspects from their specific implementations
    - Key to achieve genericity!



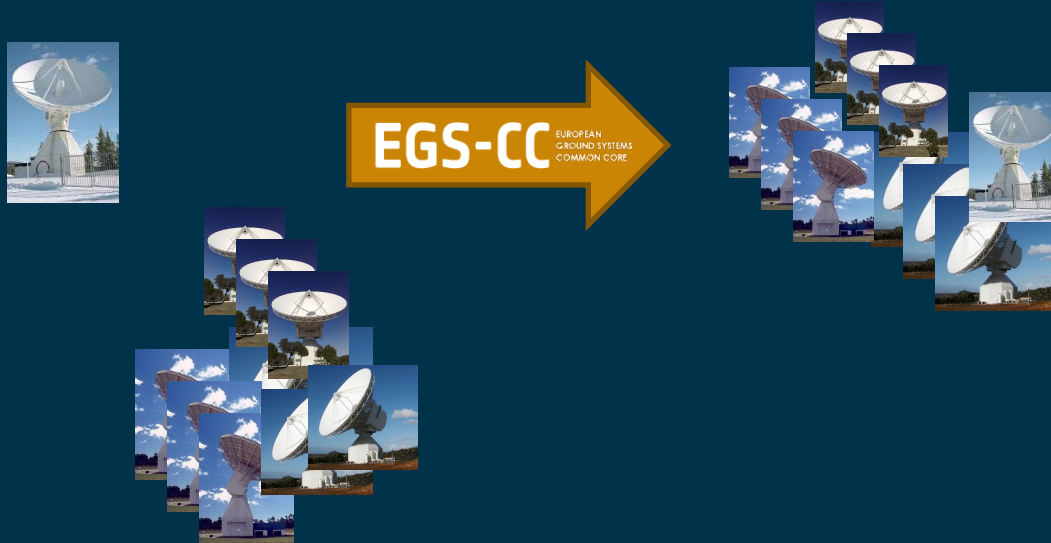
# High-level Architecture

- Layered structure composed of different building blocks
- Community approach foreseen to manage common layers
- The top layer is managed by target system responsible and end users





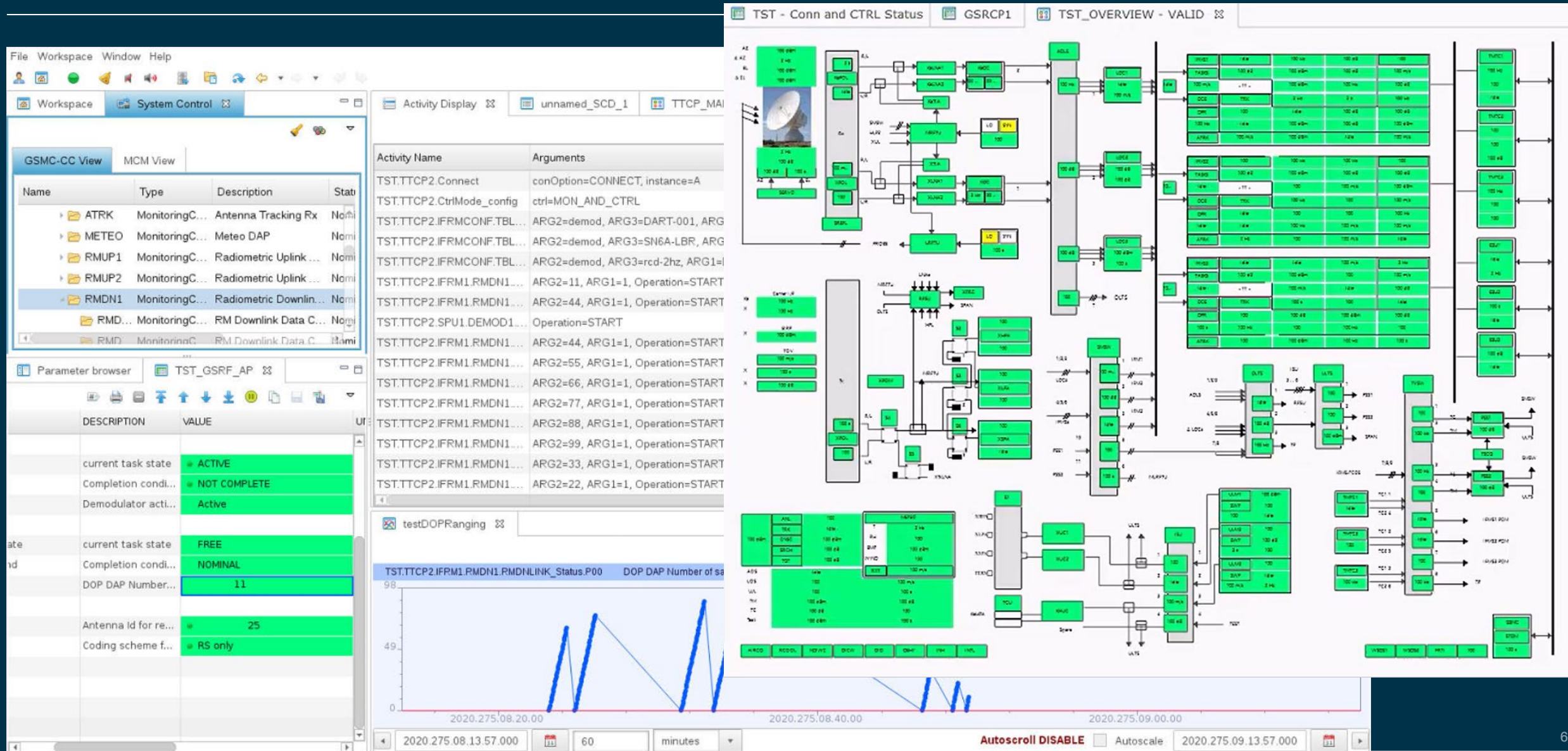
- Starting from a well-known, homogeneous environment
- Decision to keep Station Computer Language as domain specific language
  - Solution allowing for reusing procedures from the current M&C system
  - Procedure Editor provided in OPEN-S as a Station specific plugin
- Various adapter components to interface Station equipment
- Separate user interface based on EGOS User Desktop (web version)



## Many technical and organisational challenges

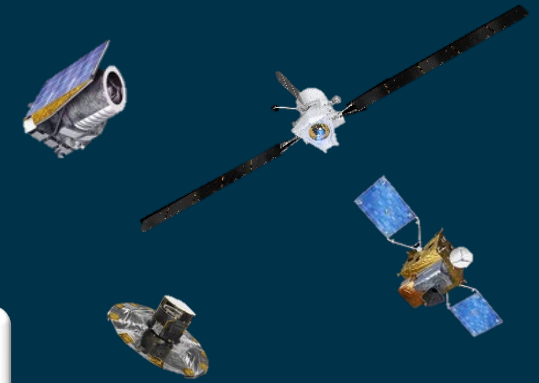
- Bandwidth limitations
- Shared concepts and framework with Mission Operations
- Retaining current tailoring data
- Migration of Ground Stations without impacting operational support

# Ground Station Monitoring & Control (cont.)





- Starting from a heterogeneous environment
  - Challenge to converge, streamline and consolidate
  - Challenge to identify and quantify differences between missions
- Creating a multi-mission infrastructure product out of mission specific needs
  - Application compositioning
  - Many interfaces to auxiliary applications
    - Flight Dynamics
    - Mission Planning
- Advanced preparation environment (OPEN-M)
  - A “must” for managing a fairly complex model
  - Integrated converter to support MIB based missions
- Extending EGS-CC with additional features
  - File-Based Operations
  - On-Board Software Management



## Many technical and organisational challenges

- Migration of flying missions
- Shared implementation with other missions and mission families
- Resources shared between missions

# Mission Operations (cont.)



Local Storage

FOP

DACG0001 - CSW Errors

DACG0008 - SC CTRL Torques

DACG0122 - IMU Set G

DACG0004 - SC Rate En File

DACG0001 - SC Estim

DACG0003 - SC Attitude

DACG0002 - SC Estim

DCDA0001 - CSW Overview

DCDA0001 - CSW TM Gene

TIC

TCD

MTT

Filter:

Search

Synoptic Row AND Plot XY

Search

Name

CSW TM Generation Setup

Name	Description
167772928	SSMM TM forward s
168036864	Nr of filtered Events

MCM Browser

Upload - Ground File Store

Upload - Onboard File Stor

FBO

File\_Management [FBO]

deleteFile [FBO]

File\_Utilisation [FBO]

activateTcFile [FBO]

generateTcFile [FBO]

uploadAndExecuteTcFile [FBO]

Uploads [FBO]

uploadFile [FBO]

Spacecraft

AOCS [Spacecraft]

APME\_HGA [Spacecraft]

APME\_MGA [Spacecraft]

Filter:

Search

Activities Events Parameters

Search

Name

Path

EGS-CC - UIF

File Edit Workbench Tools System Help

Messages Log Activities Log

TimeCorrelation

Schedules

slope	EngineeringParameterIn	1.0	VALID	Nominal	2020-10-07T16:2
validityStartCst	EngineeringParameterIn	2020-10-07T	VALID	Nominal	2020-10-07T16:2

Upload Transactions

Start Time	Transaction Id	Transaction Type	File Type	Source File	Destination	State
	1		4	data/file-4k.txt	3/50	PENDING_TRANSMISSION

Upload PDU Queue

Release Next Release All Toggle Automatic Dispatch

Transaction Id	Unit Id	Type	File	State
1	1	First Uplink Part	3/50	PENDING
1	2	Intermediate Uplink Part	3/50	PENDING
1	3	Intermediate Uplink Part	3/50	PENDING
1	4	Intermediate Uplink Part	3/50	PENDING
1	5	Intermediate Uplink Part	3/50	PENDING
1	6	Intermediate Uplink Part	3/50	PENDING
1	7	Intermediate Uplink Part	3/50	PENDING
1	8	Intermediate Uplink Part	3/50	PENDING
1	9	Intermediate Uplink Part	3/50	PENDING
1	10	Intermediate Uplink Part	3/50	PENDING
1	11	Intermediate Uplink Part	3/50	PENDING
1	12	Intermediate Uplink Part	3/50	PENDING
1	13	Intermediate Uplink Part	3/50	PENDING
1	14	Intermediate Uplink Part	3/50	PENDING
1	15	Intermediate Uplink Part	3/50	PENDING

Activities Log

Live Generation Time 2020-10-12T16:06:33.081 ~ 2020-10-12T16:09:24.665 LIVE

Name	State	Description	Processing Time	Generation Time	External Execution Time	Earliest Execution Start Time	Source ID	Route ID
OpenTcLink#688276227669	COMPLETED_SUCCESS		2020-10-12T16:06:35.985	2020-10-12T16:06:33.081	2020-10-12T16:06:33.132	2020-10-12T16:06:33.132	010f3481-6387-49f	111
OpenTmLink#688276227669	COMPLETED_SUCCESS		2020-10-12T16:06:46.646	2020-10-12T16:06:44.524	2020-10-12T16:06:44.531	2020-10-12T16:06:44.531	010f3481-6387-49f	111
uploadFile#6882762276697	EXECUTING		2020-10-12T16:09:24.914	2020-10-12T16:09:24.665	2020-10-12T16:09:24.679	2020-10-12T16:09:24.679	010f3481-6387-49f	31

Activities: 0/0

EGS-CC Schedule Tag EGS SS ID External

2020-10-07T16:23:27.869

04:23:27 PM





# Mission Operations with Bepi Colombo and Gaia



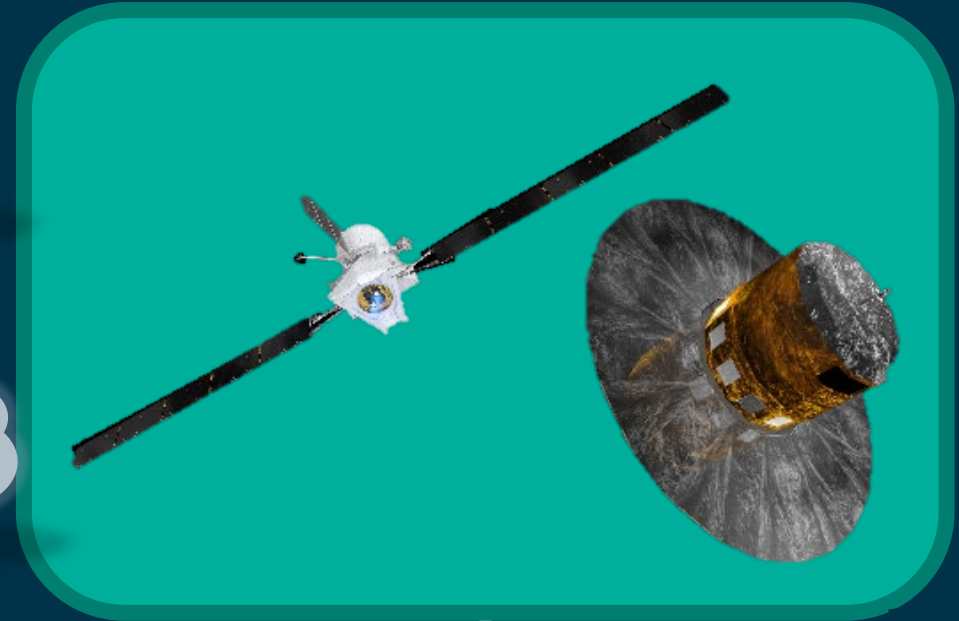
**OPEN-M**  
Preparation  
Environment for  
Missions

Mission Tailoring



Session  
BC

Session  
Gaia



Mission  
Runtime

**MCS-CC**

GAIA  
Simulator

BC  
Simulator

Several missions can be controlled  
from the same MCS-CC installation  
– using different sessions





- We have succeeded in creating a generic control system
  - Genericity comes with complexity
    - High learning curve – slow familiarisation
- A technically feasible solution is not sufficient
  - A change of culture is needed for shared implementations and shared environments
- Repeated demonstrations show that a multi-mission set-up is feasible with the chosen solution

**With a technical solution providing the necessary support,  
time is ripe for a change of mind-set**

Yes, we can!



# Thanks for your attention!

Related presentations at GSAW 2021:

- ♣ *An Operations Preparation Ecosystem*
- ♣ *From Mission-Centric towards Infrastructure-Centric Processes and Services*

*We would like to acknowledge the excellent work of all the EGOS-CC project team members. A special thanks to Joao Matos who supported recording of the video.*

Klara Widegård, Mauro Pecchioli, Anthony Walsh– European Space Agency

Ground System Architectures Workshop - GSAW 2021

12