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Executive Summary Report

Mission Families: From Common Software to Common Operations

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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

This document is the **Executive Summary Report** of the activity “Mission Families: From Common Software to Common Operations” (CSTOCO). It provides an overview and summary of the activities done and results.

1.2. APPLICABLE DOCUMENTS

ID	TITLE	REFERENCE
AD-1	STATEMENT OF WORK Mission Families: From Common Software to Common Operations	ESA-DOPS-STU-SOW-0035, V1.0, 31/03/2021

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2. CONTEXT AND OBJECTIVE

ESA has achieved a significant level of **commonality** across missions up to date, and in particular when missions belong to the same category or family. Commonality results in reuse and thus in cost reduction. **Different mechanisms** have been used to achieve commonality, both on the ground and space segments, like standardisation of interfaces, services and building reusable software components.

This study has gone a step forward in the application of common concepts, around the mission operations, in which effort intensive activities are currently performed for the preparation of mission operations. This is intended to be achieved by **reusing the operational artefacts across missions**, minimising the need to develop, validate, integrate, and document operations artefacts, as well as train operators for their usage.

This potential common approach for operational artefacts would allow a further application of a multi-mission concept, which would cover common software, common multi-mission platforms, and ultimately **common operational artefacts and procedures**.

The concept of reusing mission operations artefacts in a significant extent is **possible thanks to** the similarity of operations concepts and ways to interact between the spacecraft and the ground. In addition, the new European Ground Systems Common Core (EGS-CC) system service-oriented architecture and concept is a key enabler for allowing to share operational artefacts for different missions which have their own mission specific packet definitions which implement them. The possibility to interact with EGS-CC by using abstract concepts, and the provision of services which implement internally mission operations permit the definition of the artefacts in a way they can be shared and applied unchanged to different missions.

This study has explored the existing EGS-CC mechanisms and used them to resolve the link between the generic and common concepts with their mission specific implementation.

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3. OVERVIEW OF THE ACTIVITY

3.1. PROGRAMME OF WORK

In order to achieve the objective of the study, the work breakdown was structured in four **major tasks** as follows:

- TASK 1: Analyse of commonality in mission operations
- TASK 2: Definition of a Routine Operations Reference Model
- TASK 3: Production of CDM Compatible Tailoring Data covering the Reference Model
- TASK 4: Validation of the Reference Model and associated Tailoring Data

The **task 1** performed an overall analysis of the operations and EGS-CC services capabilities, addressing progressively the different concepts. For the analysis of operations, a number of ESA missions from different categories were analysed in a structured way, for the purpose of identifying which routine operations exhibit a higher degree of commonalities across missions. The objective of the task was to produce a backlog of operations to consider as candidates for the common tailoring data.

The **task 2** defined a design approach for the reference model, that is, technical solutions for the common tailoring data. In addition to a general technical approach, the operations selected in task 1 were analysed, and a technical solution was appointed for the data elements in each operation.

Following the technical solution defined in task 2, the **task 3** produced a set of common tailoring data for the operations selected in task 1. The output of task 2 is a TDM-compatible common tailoring data for the various operations: activities, arguments, parameters, displays, activity lists, etc. Additionally, an activity list was also produced to support a generic pass execution macro-activity which be used in a routine pass by any mission.

Finally, in **task 4** the common tailoring data has been integrated into two missions, namely, Swarm and Bepi-Colombo, for validation purposes. The validation has been organised at two levels: verification of the syntactical correctness of the common tailoring data, and validation in representative scenarios from the operations point of view.

3.2. ANALYSIS OF MISSION OPERATIONS CONCEPTS

The main objective of this analysis was to identify the set of activities that could be executed in a common standardised procedure by all (or many) missions operated at ESOC.

In order to structure the analysis, several **subjects of interest** were identified as representative and were addressed as a start point for the discussion in the mission specific context. Moreover, ESA missions were grouped in four **mission families**: astronomy, planetary, Earth observation and Copernicus.

On the other hand, several teams were identified to help and contribute on the definition of the possible **activities that could be common** in mission operations. Iterations across different meetings and two workshops allowed to assign priorities to the different operational activities. The selection criteria included both an operational perspective and an implementation perspective.

The analysis concluded with the selection of the elements summarised in the following table:

IDENTIFICATION OF OPERATIONS		PRIORISATION
CATEGORY	OPERATIONAL ACTIVITY	
File-based operations	FBO file transaction and management	HIGH
	FBO TC and TM files processing	HIGH

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IDENTIFICATION OF OPERATIONS		PRIORISATION
CATEGORY	OPERATIONAL ACTIVITY	
On-board schedule management	Uplink of on-board schedule contents	HIGH
	Management of the on-board schedule	HIGH
	Management of ground model	MEDIUM
Routine	Generic pass execution macro-activity	HIGH
	Ground station links management	HIGH
	Time correlation management	HIGH
	Commanding loop/directives	HIGH
	Basic pass activities	HIGH
	Mass memory operations and maintenance	MEDIUM

3.3. ROUTINE OPERATIONS REFERENCE MODEL

The routine operations reference model defines the design to implement an instance of the EGS-CC tailoring data model (TDM) to support common operations.

One of the lessons learnt in the analysis of mission operations is that the degree of commonality in operations across different missions is higher in **routine** operations. Operations addressing payload management and contingency scenarios are mission specific to a larger extent. Hence, in the frame of the study the scope of the reference model is focused on routine operations.

The reference model is understood as the **definition of the principles to model the operations as abstract generic tailoring data** so it can be translated into the implementing functions in EGS-CC. The information must be organised in a way it is understood from operations point of view, and using the Tailoring Data Model of EGS-CC (TDM) to define the tailoring data.

The common tailoring data is intended to deliver a set of definitions already prepared and validated, which can be integrated with mission specific tailoring data, to produce the operations baseline configurations. The tailoring data is managed in the preparation environment OPEN-M, and it is applied to the runtime EGS-CC based system for the execution of the operations.

The **key concepts** of the TDM which are exploited in the definition of the reference model are:

- Separation between monitoring and control entities (like activities or parameters) and implementation assets (like packetization layer).
- Mappers linking definitions and implementations.
- Configuration items, the central elements for configuration control tracking.

The structure of the reference model can be described in a dual way, from a logical/conceptual perspective and from an implementation perspective. The **logical view** shows the conceptual relationships between entities and the **physical view** shows how the model is arranged in separate resource files.

3.4. THE COMMON TAILORING DATA

The production of the common tailoring data was carried out following the strategies defined in the routine operations reference model, and using the operations preparation tool **OPEN-M**.

The individual tailoring data elements have been created either from scratch or based on existing elements, as copies or clones of them.

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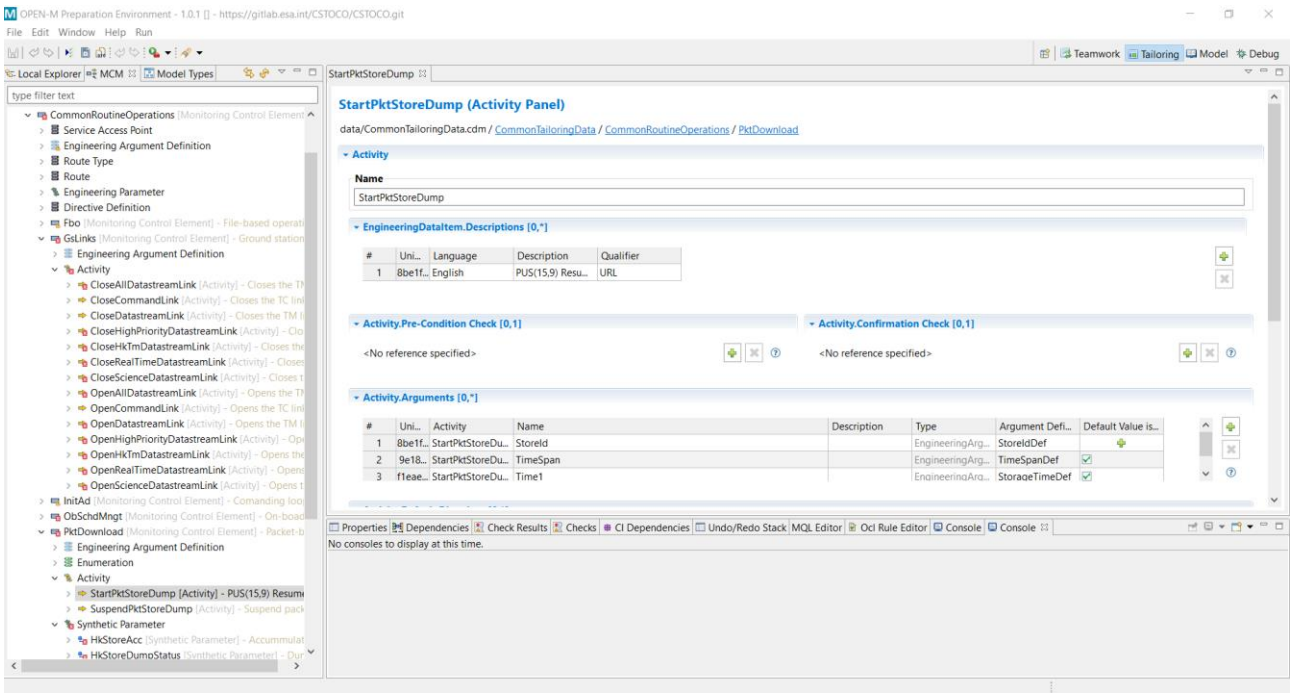
The data elements of the common tailoring data are grouped into several functional areas, which correspond to the **operations areas** identified in the analysis of commonalities in mission operations:

- G/S links management
- Time correlation
- Commanding loop/directives
- Packet-based data download
- On-board schedule management
- Stack file upload
- File-based operations

The following figure shows the MCM view of OPEN-M, where some of the elements are unfolded on the MCM tree and an activity is shown on the form editor.



A **validation** of the common tailoring data was undertaken by exercising the tailoring data from the operational point of view, using real missions and scenarios. Two reference missions from different families have been used for the validation: Swarm and Bepi-Colombo.

The testing and validation has been performed at two different levels:

- **Verification level**: oriented to prove the correctness of the tailoring data.
- **Operational validation level**: oriented to the execution of operationally realistic scenarios using the EGOS-CC setup, the integrated tailoring data, and the corresponding simulators.

Before it can be used, the common tailoring data needs to be integrated with the mission tailoring data, and the mappings between them resolved.

After the common tailoring data is integrated into the tailoring data of a mission, when the mission tailoring data is deployed, it can be used on the runtime system in the same way as any other tailoring data elements of the mission.

The following picture shows a version of the MCS-CC of Bepi-Colombo with some elements of the common tailoring data loaded on some components.

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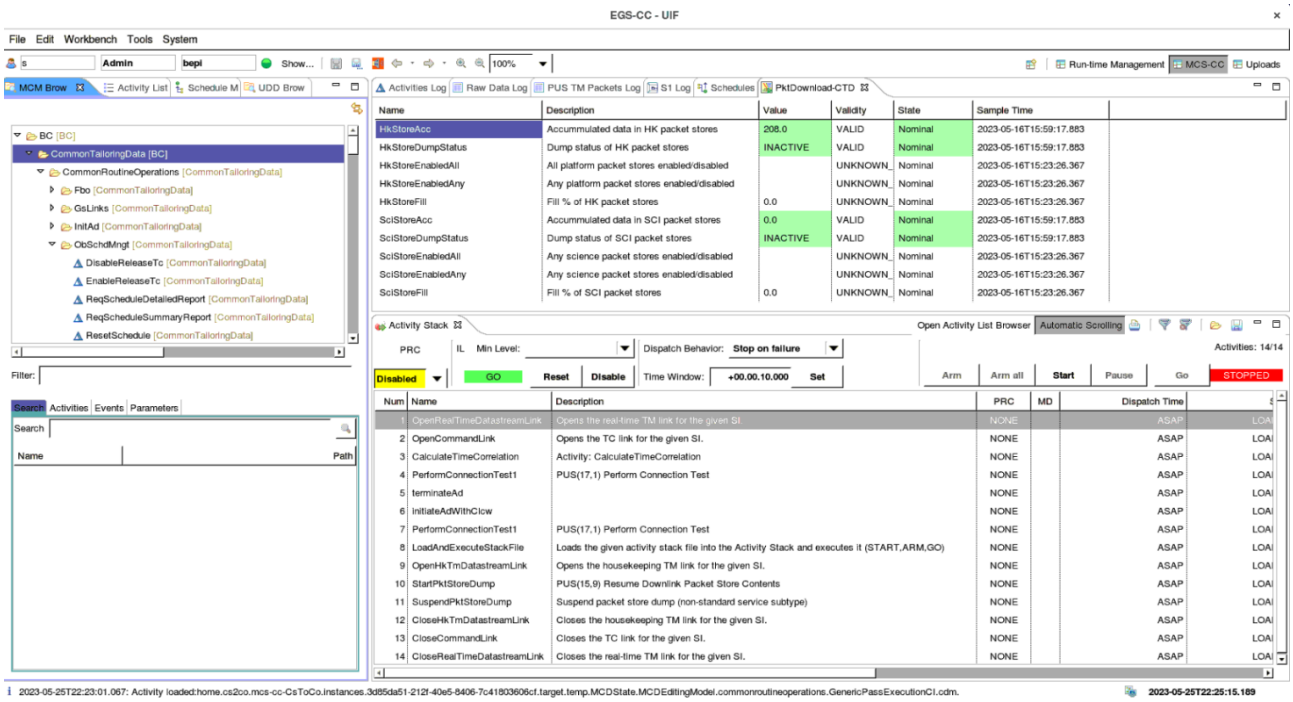

3.5. GENERIC PASS EXECUTION MACRO-ACTIVITY

One of the main targets identified during the analysis phase, was the implementation of a so-called generic pass execution macro-activity (or generic pass, for short), as an operational artefact covering some of the main common tasks executed by missions during a pass.

Later in the project, a further exercise was identified, in the line of generating such generic pass as a generic procedure using the Procedures Editor, part of the OPEN-M environment.

The implementation of the generic pass has been based on a plan split into two steps:

- 1. Production of a **manual generic pass**.
- 2. Production of an **automated generic pass** and compare it with the manual generic pass.

The manual generic pass consists of the following elements:

- A manual procedure written with the Jira Test Management Tool. It is similar to the operational validation test cases. In fact, it massively reuses steps taken from the validation test procedures.
- A “generic pass” activity list. This is a new element of the CTD, containing previous created common activities.
- Other CTD elements: UDDs, synthetic parameters and individual activities.

The automated generic pass consists of the following elements:

- An ATOP procedure written using the OPEN-M Procedure Editor.
- An activity list exported from the ATOP procedure.

The manual generic pass was successfully tested on both Swarm and Bepi-Colombo MCS-CC.

The automated generic pass was checked by verifying that the activity list generated from it and the activity list that was manually written for the manual generic pass are essentially identical. This is considered a successful proof of concept of using the ATOP language and the OPEN-M Procedure Editor for the concept of the generic pass execution macro-activity.

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4. CONCLUSIONS

The activity has taken the EGOS-CC multi-mission concept one step further by defining a reference model for routine operations and building a reusable common tailoring data. This outcome paves the path for cost reduction in the preparation of the operations of future ESA missions.

The reference model relies on the tailoring capabilities of the EGS-CC architecture, and it is based on the layered structure of the Tailoring Data Model (TDM) of EGS-CC. The reference model defines technical approaches to comprise a solution for the production of common tailoring data.

An integration procedure has been defined for the integration of the common tailoring data into the tailoring data of a mission. The practical aspects related to the usage and maintenance of the common tailoring data are covered by a user manual.

A proof-of-concept generic pass execution macro-activity, which had been identified as a major target during the analysis of mission operations concepts, has been eventually implemented as a composite of common activities implemented through the production phase of the project and taken as building blocks, and it has been successfully tested.

As a follow on of this study many future steps are promising, like additional validation activities, addition of more common elements and consolidation and evolution of the generic pass concept.

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