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DOCUMENT

DIGITAL GROUND SEGMENT OPERATIONS FOR PHASE 0/A - EGSM

EXECUTIVE SUMMARY

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Reference	**ESA-DOPS-STU-EX-0001**
Issue / Revision	**1 / 2**
Date of Issue	**2023-10-13**
Status	**RELEASED**
Document Type	**ES**
Distribution	**-**
Contract	**4000138141/NL/GLC/mkn**

European Space Agency
Agence spatiale européenne

APPROVAL

Title EGSM Final Report	
Issue 1	**Revision** 2
Author DGSO Team	**Date** 2023-09-19
Approved by Marcus Wallum . . .	**Date** 2023-09-19

CHANGE LOG

Reason for change	**Issue**	**Revision**	**Date**
Initial version	1	0	2023-09-04
Version after AR	1	1	2023-09-19
Change name of funding programme	1	2	2023-10-13

CHANGE RECORD

Issue 1	**Revision** 2		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Initial version	2023-09-04	All	All
Version after AR: -review of syntax and content	2023-09-19	All	All
Version for closure: -change name of program from GSTP to Discovery of DPTD	2023-10-13	3	1

1. EXECUTIVE SUMMARY

This document presents the achievements of the Digital Ground Segment Operations For Phase 0/A (DGSO) project, funded by the Discovery element of ESA DPTD (Discovery, Preparation and Technology Development and undertaken by RHEA Group and TU Darmstadt.

Documents are currently the preferred information exchange and distribution mechanism However maintenance, change traceability and cross referencing in documents is almost impossible to achieve. Thus, increasing not only the costs during the analysis stages but also the possibility of errors and use of outdated information.

The aim of DGSO and related activities is to enable a transition, for all ESA missions, of the ground segment systems engineering domain to a fully model-centric approach, and for DGSO this effort is focused on the transition to a model-centric approach for the artefacts used and generated during the phase 0/A of a space mission.

GS&OPS are already addressed to a limited degree in Concurrent Design activities performed at ESA's Concurrent Design Facility (CDF) but the results are not readily transferrable to subsequent phases (except as documents). This is the gap that DGSO project tries to target.

DGSO is a new tendered activity scoped within the ESA Discovery Preparation and Technology Development (DPTD) activities. It leverages the work performed on the ADGE project which is a follow on activity of the Paperless End-to-End Ground Segment Engineering (PLGSE) study within the ESA Technology Development Element program and aims to maintain the TRL of ADGE but demonstrate it for the new artefacts.

The activity started in July 2022 and has been completed in September 2023, which lengths a total duration of 14 months. During the first 2 months of the project, the consortium performed an analysis of the state of the art of the processes involved on phases 0/A. As such, this included analysis of the current MBSE use artefacts involved and user stories of their day to day work and pain points. Furthermore, a review of the existing MBSE (Model-Based System Engineering) tools, the features they provided and also their development and maintenance status. It also included a series of interview with relevant stakeholders to define their Point of view regarding MBSE topics and their expectations for a tool to help them during the targeted phases. During the analysis it was decided to target the formal definition of the MOAD (Mission Operations Assumptions Document), S2G ICD (Space to Ground Interface Control Document) Part 1 and 10-25 Product Tree Artefacts as more impactful elements during the phases 0/A. Furthermore, it was also decided to use the ongoing ADGE development of the GSEF tool as the baseline, and thus enhancing the existing metamodel with the three selected artefacts semantics be done in SysMLv2 language.

The data modelling and the requirement elicitation was performed over the following next two months. The most challenging part of this phase was learning SysMLv2 and its syntax language KerML, as it was still being defined. Also compliance to the modelling way of ADGE had to be performed. Several iterations were performed within the consortium on the model review, but also review and support by the Agency and the ADGE team to align perspectives and have an agreement on the modelling way. That's why dedicated technical notes for the modelling and example of the mapping with input test data was performed explaining how the modelling covered the needs. Most of the effort on the modelling was spent of the agreement of the granularity of the semantics for the MOAD, the S2G ICD and the Product Tree and their mapping to the provided real mission artefact documents.

The development of the enhancement of GSEF for the new metamodel has extended over a period of 10 months. The result of this work was the needed GSEF configuration to

allow the authoring, exchange and reporting of the selected artefacts to be demonstrated. The last part of this development was allowing the interfacing between GSEF and COMET tools, to support the reporting and transition of the product trees from the CDF sessions towards the development, validation and operational Phases. These functions were validated with the same system engineers which were interviewed at the start of the project to verify whether they though the tool was useful and which parts could be improved on the future.

The interfacing with COMET is important because it integrated one of the main activities being performed during Phases 0/A. But also, it will allow, in the future, interfacing with SSO (Space System Ontology) as the MBSEHub tool (based on SSO) being developed lead by ESTEC will connect to COMET and COMET to GSEF.

The biggest issues experienced during the activity was the instability of GSEF and SysMLv2 during development as both were also ongoing in parallel with no clear and maintained schedules. This led to a high consumption of the budget and time on continuously validating GSEF itself and having to rescope and prioritize the demonstrations. Moreover, due to this prioritization, upgrades to support units on the tool, include static validation, interfacing with other tools (Budget Link Tools, MBSEHub) and considerations of other models (e.g. SSO) which could have been incorporated, were put into the backlog enhancements as lessons learned and roadmap tasks to be implemented in the future.

Nevertheless, it can be concluded that DGSO-A activity has successfully leveraged GSEF and advanced the efficiency and effectiveness of space mission planning and operations through the development and demonstration of the EGSM software. It has been positively received by end users as a first step to bring new interfacing and more conventions, marking a significant milestone in the digitalisation of the ground segment & operations integration in early phase 0/A studies.