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MBSE Best Practices Project

OSIP Study
Harmonising MBSE standards into ECSS

CGI Executive Summary

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1 Acronyms

Acronym	Definition
ADS	Airbus Defence & Space
DoDAF	Department of Defence Architecture Framework
ECSS	European Cooperation for Space Standardization
ESA	European Space Agency
ESOC	European Space Operations Centre
GSEF	Ground Segment Engineering Framework
INCOSE	International Council on Systems Engineering
LSIs	Large Space Integrators
MBSE	Model-Based Systems Engineering
MB4SE	MBSE Advisory Group
MOFLT	Mission / Operation / Function / Logical / Technical methodology
OOSEM	Object-Oriented Systems Engineering Method
PLGSE	Paperless Ground Segment Engineering
RAMS	Reliability, Availability, Maintainability and Safety
SECAM	Systems Engineering Core Architecture Model
SysML	Systems Modelling Language
TAS	Thales Alenia Space
TOGAF	The Open Group Architecture Framework

2 Executive Summary

The European Space Agency (ESA) has traditionally specified space system using a document-based approach, and is now in a transition process towards the digitalization of the systems engineering activities. At the same time, space industry companies have their own internal set of best practices and experience with Model Based Systems Engineering (MBSE). To solve this problem, ESA initiated this study led by CGI in partnership with OHB to identify a way to harmonise the different MBSE approaches from industry and compile the information into a concise book.

Different MBSE approaches, methods, and tools were documented in the context of Space Systems and the commonalities and differences are highlighted in relation to applying MBSE in Space applications. The study looked into Model Governance, Requirements Management, Problem Space/Specification, and Solution Space/Design. Additionally it presents the relation between the MBSE Modelling Artefacts against the ECSS deliverables as defined in the ECSS-E-10 standard. Finally, the study provides a way forward in the production of ECSS conformant documentation, using as only source the contents of a model.

Many companies, especially in the Aerospace industry, use MBSE to design and develop their advanced systems. Model based techniques facilitate and significantly enhance the understanding of a system and its behaviour, providing rich capabilities to represent complex systems. MBSE enforce structure and precision, being extremely useful for the integration across the system life cycle and across multiple domains. However, the multitude of MBSE approaches and best practices is as broad as the different engineering topics.

ESA’s systems are composed of many different elements, being developed by different entities and currently the only apparent way of integrating them is via written documentation. There have been initiatives during the past decades, aiming at defining models and tooling able to support the various needs of the system engineering process.

In the MB4SE Advisory Group, it has been suggested to standardize all the Space Industry on the use of the ARCADIA method but unfortunately this effort did not succeed because the Large System Integrators (LSIs) already have their own well-defined methods.

There are on-going activities currently attempting to develop a common architecture and understanding of how MBSE will look like in the future and for which use cases it will be applied in the European space community, also involving surveys among the main stakeholders. The proposed activity shares some similarities with this methodology, but puts the focus more on the engineering level, aiming at practical guidance and best practices to be harmonized and shared for MBSE practitioners. This will create a real benefit to the investigations from other activities with a more global focus.

The main objective of this study activity was the creation of a MBSE Best Practices collection document that describes:

- how the Systems Engineering tasks (as per ECSS – E-ST-10-C Rev. 1) can be best achieved with MBSE support;
- the recommended methods for using MBSE in Space Projects and focusing on the engineering level, aiming at practical guidance;
- best practices to be identified, harmonized, and shared among the MBSE practitioners.

The compiled feedback is agnostic from any particular MBSE tooling, while respecting already existing assets such as tooling and specific in-house methodologies. In order to do this, the study activity prepared a Survey Questionnaire and distributed to the main stakeholders of the MB4SE Advisory Group (Airbus, Thales, OHB, and ESA). A set of follow-up Interviews with the involved stakeholders were performed in order to guarantee that all the queried information was correctly understood. This process in depicted in Figure 1.

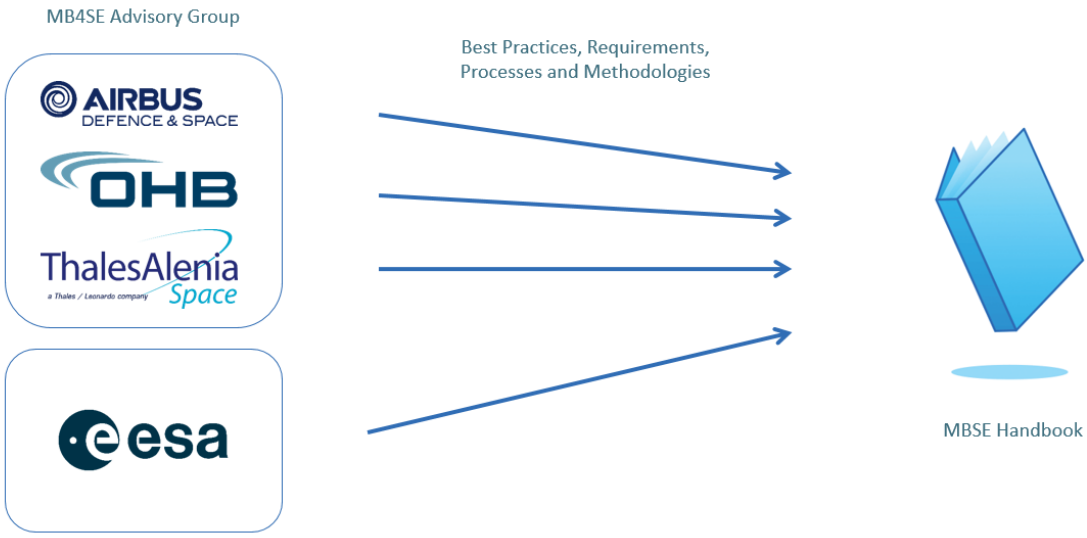

Figure 1: Study activity querying information from the main MB4SE stakeholders

MBSE has been practiced for more than 10 years in the space industry, especially by Thales Alenia Space (TAS) and Airbus Defence and Space (ADS) who have developed their own methodologies and toolchains. TAS developed the ARChitecture Analysis & Design Integrated Approach also known as **ARCADIA**, and ADS created the Mission / Operation / Function / Logical / Technical methodology also known as **MOFLT** and the Systems Engineering Core Architecture (SECAM) Model. The ARCADIA methodology is also used by other entities in the space industry, because it is implemented in the open-source tool Capella.

In the European Space Agency (ESA), specific methodologies were developed in the frame of specific projects, which are often formalized into SysML profiles or reuse methodologies embedded in the tools of choice (e.g. ARCADIA, Vitech). For example, the European Space Operations Centre (ESOC) has developed via the PLGSE/GSEF activities, a formalized methodology for ground segment design and development, and a metamodel starting formally from ECSS processes and deriving it from them. Even though multiple initiatives exist at project level, there is not yet a formalised MBSE methodology at ESA organisation level.
The general MBSE process, mostly reflects internal processes to the different entities and ECSS when applicable. They are all heavily based on standard languages, primarily SysML. Sometimes, custom-specific features are defined depending on organizational needs and particularities.

Figure 1 presents a high level comparison of MOFLT (from ADS) and ARCADIA (from TAS). While in principle the two methods are following a similar approach, there are some differences in the structure of the process phases including their particular scopes, also in the involved terms and in some particular design rules applied with respect to the process, which does not allow for a simple one-to-one mapping.

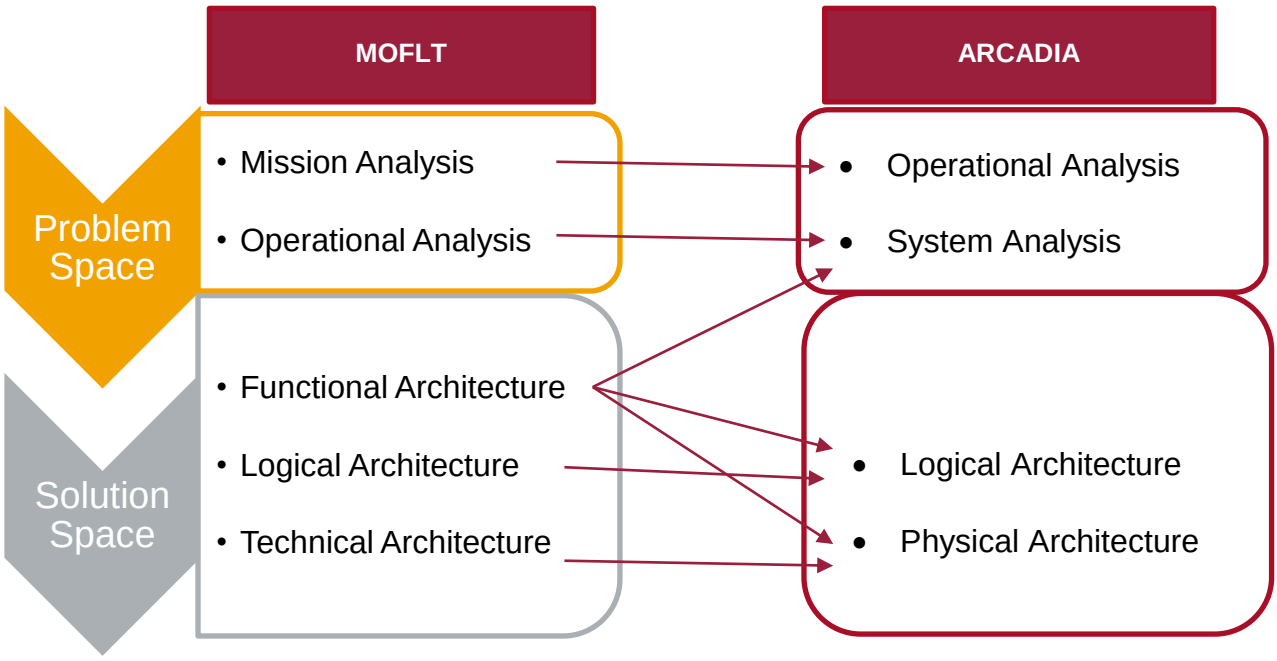

Figure 2: MOFLT vs. ARCADIA

During the study activity a set of 35 best practices were identified, covering the following domains:

- General MBSE Best Practices
- Requirements Management
- Mission Analysis
- Operational Analysis
- Functional Architecture
- Logical Architecture

The interviewed stakeholders mentioned some common inputs when defining their specific MBSE methodology. These were:

- Space Standards (ECSS E-10, ECSS E-70)
- existing methodologies (ARCADIA, INCOSE OOSEM)
- Architecture Frameworks (TOGAF, DoDAF etc.)

The defined MBSE methodology should be tailored to the organization's needs, but it is not dedicated to a specific product. Tailoring happens for different projects with a common core optimized for the organization's needs. It can also be used outside, to establish a reference vision and semantics to talk about MBSE with the different partners and subcontractors in the supply chain. Still each organization will have its own methods, but standardization may be achieved with respect to data formats and exchange. This standardization, through a common ontology and exchange formats is on-going in several activities stemming from the MB4SE Advisory Group and the MBSE Technology Harmonization roadmap. As part of these activities, the MBSE Best Practices collection will be enhanced also with other topics, such as: Physical Architecture, Interfaces Definition, RAMS Analysis & Model-Based Safety Analysis, Integration, Verification & Validation & Operations.