Towards a MBSE Best Practices Book for Space Projects

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Abstract Many companies, especially in Automotive and the Aerospace industry, use Model-Based System Engineering (MBSE) to design and develop their systems. However, the multitude of MBSE approaches and best practices is as broad as the different engineering topics. 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 MBSE. To solve this problem, ESA initiated a 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 are documented in the context of Space Systems and the commonalities and differences will be 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. A follow-up activity is expected in order to expand the contents of the MBSE Best Practices Book for Space Projects.

1. INTRODUCTION

The use of Model Based Systems Engineering (MBSE) to design and develop systems has been increasing in the Space industry over the past few years. Model-based techniques facilitate and significantly enhance the understanding of a system and its behaviour, providing rich capabilities to represent complex systems.

MBSE enforces structure and precision, being 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.

The main objectives of the MBSE Best Practices Handbook is to describe:

- how the Systems Engineering tasks (as per ECSS – E-ST-10-C) can be best achieved with MBSE support; [1]
- the recommended methods for using MBSE in Space Projects and focusing on the engineering level, aiming at practical guidance; [2] [3] [4]
- 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 software applications and specific in-house methodologies. The study queried information through a Survey Questionnaire and through follow-up Interviews from Thales Alenia Space (TAS), Airbus Defence and Space (ADS), OHB, and ESA. The study is depicted in the figure below.

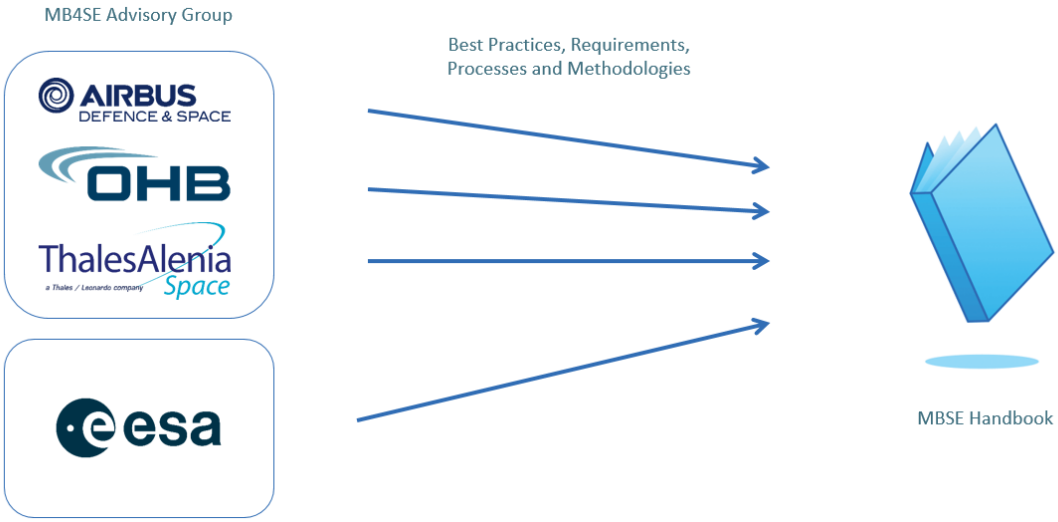

Figure 1: High-level visualization of the Study

2. OVERVIEW OF THE ANALYSED MBSE METHODS

MBSE has been practiced for more than 10 years in the space industry, especially by TAS and 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. [5]

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. [6]

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 2 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.

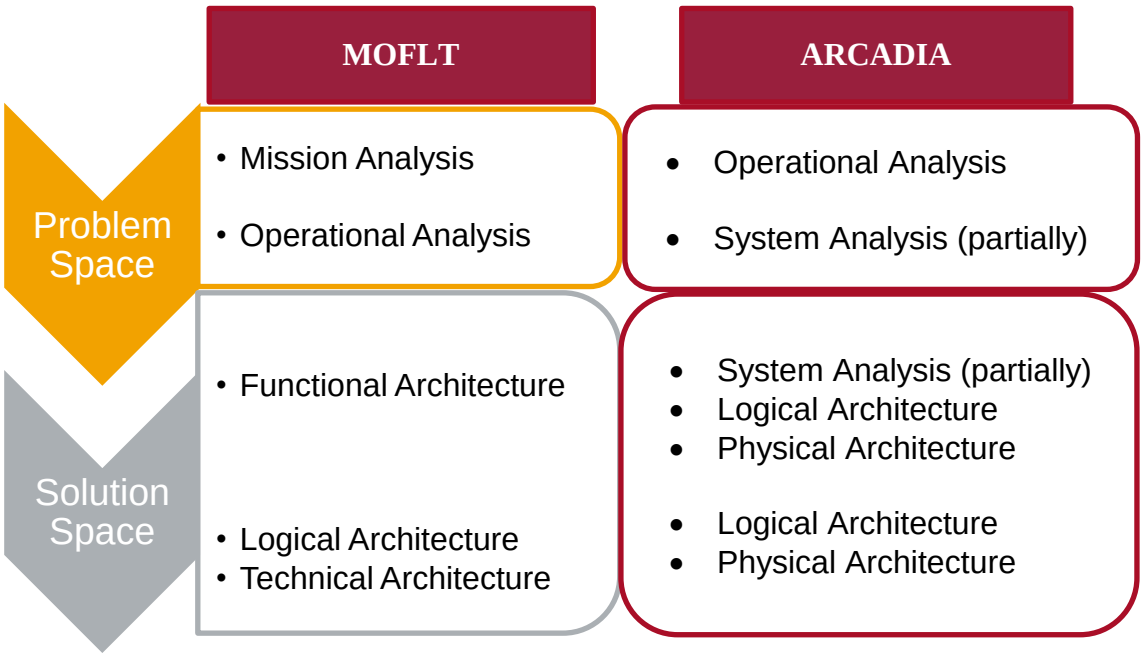

Figure 3: MOFLT vs. ARCADIA

3. CONCLUSION

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.

4. REFERENCES

[1] ECSS - System engineering general requirements, ECSS-E-ST-10C Rev1, 17/02/2017

[2] ECSS - Space Engineering – Ground systems and operations, ECSS-E-ST-70C, 31/07/2008

[3] ECSS - System engineering guidelines, ECSS-E-HB-10A - Draft version 1

[4] Generic ESA SysML Metamodel and Toolbox for Space Systems Modelling, EUCL-EST-TN-1-014, 14/08/2017

[5] ARCADIA Datasheet

[6] Towards a definition of best practices for Model Based Systems Engineering in European Space Agency Projects, AIAA 2018-5327, 15/09/2018