ESA SysML Solution

Abstract for MBSE2022

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Workshop Objectives: O-1 / O-2 / O-3 / O-4 / O-5 / S-1 / S-2

Abstract

1. Introduction

The *ESA SysML Solution* is a pragmatic Model-Based System Engineering (MBSE) solution, tailored to the needs of ESA Space Projects. The solution is composed of:

- an MBSE methodology and conceptual data model specification derived from European Coordination for Space Standardization (ECSS) standards.
- a target language mapping to Object Modelling Group (OMG) Systems Modelling Language (SysML) V1 [1].
- a customised tool implementation in the system modelling tool Dassault Systèmes Cameo Systems Modeler (CSM) [2].
- a demonstration model (implemented in CSM).

The ESA SysML Solution is the successor to the “ESA SysML Profile”/“ESA SysML Toolbox”, which has been in operational use in ESA Science missions since 2016 [3]. Development of the ESA SysML Solution occurred over 2021-2022, with initial release in the first quarter of 2022.

2. Development and Deployment

In the authors previous presentation at MBSE2021, “ESA MBSE Evolution: From ESA SysML Toolbox to ESA MBSE Solution”, key gaps were identified with the “ESA SysML Toolbox” with

respect to conceptual grounding, ECSS compliance, reusability across projects, and a lack of structured methodology to support engineers. [4] The authors outlined their plan for the evolution of the previous work and presented a rigorous approach to definition of the next iteration. This work involved process modelling of the System Engineering workflow and the data products involved (as defined by ECSS standards), specification of a conceptual data model and a guiding methodology, mapping to a target language (SysML V1), and implementation in the CSM toolset, requiring profiling of SysML with additional configuration/customisation of the toolset. Verification of the solution was performed by adapting the outputs of the MBSE Demonstrator Concurrent Design Facility study [5] and providing a new implementation in a CSM system model, extending it to exercise all aspects of the methodology. The result of this work is the ESA SysML Solution, which received a first release in February 2022 under ESA Software Community License – Type 2 in the European Space Software Repository (ESSR) [6]. This paper presents technical details on all components of the resulting solution.

The ESA SysML Solution is now in operational use in the European Large Logistics Lander (EL3) and Generic Operations Interface Requirements Document (OIRD) projects. The solution was also used to create additional functional and physical architecture model outputs as part of the Mars Communication and Navigation Infrastructure (MARCONI) feasibility study, for input into Phase A. Application of the solution in further ESA projects is envisaged over the course of 2022 and beyond.

3. R&D and Future Evolution

Relevant ongoing and planned activities are part of the Overall Semantic Modelling for System Engineering (OSMoSE) initiative [7] to develop a common ontology (semantic data model), called the Space System Ontology (SSO), to facilitate model-based exchanges. The ESA SysML Solution is one of the stakeholders of this working group (Figure 1). An ORM (Object-Role Modelling) ontological model of the ESA SysML Solution has been created to be aligned with OSMoSE.

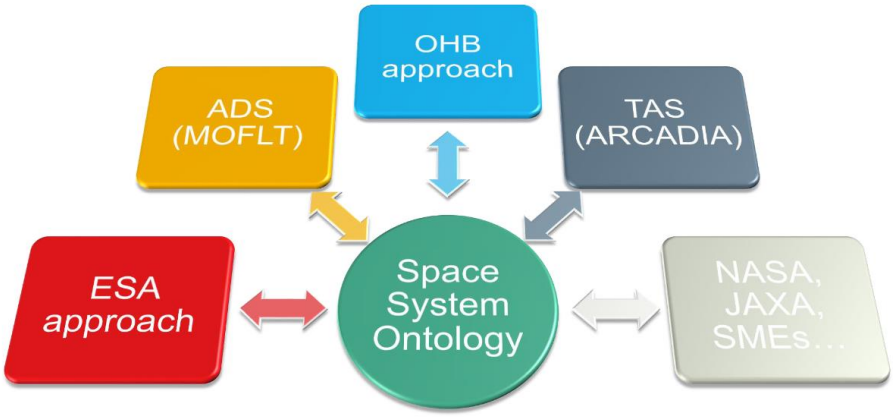

Figure 1: The Space System Ontology as a means to allow interoperability between different MBSE approaches

As part of work packages on Mars Sample Return – Earth Return Orbiter project, Airbus Defence and Space (ADS) will perform a direct comparison of the ESA SysML Solution to ADS R-MOFLT and, in addition, create a prototype model-to-model transformation tool. This shall serve as an external conceptual validation of the solution, inform interoperability concerns by indicating key areas of conceptual alignment and divergence, and investigate potential approaches to model integration in future missions. This work package is due to complete in advance of the MBSE2022 conference and results shall be presented.

The future maintenance and evolution of the ESA SysML Solution shall be performed by the "ESA SysML Solution: Specification and Implementation" activity, intended to run for a duration of 18 months with kick-off in Q4 2022. This activity shall incorporate Interface and Verification/Validation concepts which were not considered in the first release, provide an additional implementation in the Sparx Systems Enterprise Architect toolset [8] for use in ESA Science projects, and investigate potential targeting to SysML V2 [9] in the future. At time of writing the activity is still in the tendering process, which is expected to complete in advance of the MBSE2022 conference, and full details on the contract and development timeline shall be presented.

4. Conclusion

This paper presents the results of the development work on the ESA SysML Solution, which ensures compliance with ECSS standards, provides a guiding methodology for practitioners, and delivers a ready-to-use implementation for operational use in ESA Projects. It describes

all components of the solution and the technical detail of their specification and implementation. This paper also reports on the practical application of the solution to projects and initial feedback from its operational use. Finally, this paper outlines the integration and future evolution of the ESA SysML Solution as part of ongoing and planned research activities. This contributes towards ESA's Digitalisation objectives as part of Agenda 2025. [10]

References

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