ESA MBSE Evolution: From ESA SysML Toolbox to ESA MBSE Solution

Paper proposal for MBSE2021 Conference

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In the European Space Agency, a variety of MBSE methodologies and tools are currently used depending on the project or space mission. Over the last 5 years, there has been an initiative to create a customized version of the OMG Systems Modelling Language (SysML) to adapt it to the needs of space projects. This is known as the "ESA SysML Profile", while the implementation of this Profile in SysML-based modelling tools, namely Enterprise Architect and Cameo Systems Modeler, is known as the "ESA SysML Toolbox". This has given projects with a language and a tool to implement MBSE with some success.
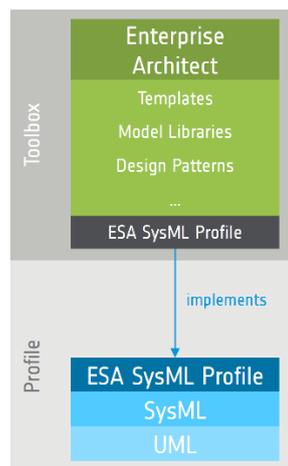

Figure 1 - ESA SysML Profile / Toolbox

However, a key component of the overall ESA solution is missing: the methodology. The need for a common methodology for ESA MBSE implementations to ensure (re)usability, consistency and correctness has become a primary concern. Alongside this, deficiencies in the current implementation of the ESA SysML Profile, arising out of its origins as a project-specific effort and an increased dependency from other tool interfaces, have led to the need to evolve the profile to ensure reusability across projects.

The missing components of the current MBSE approach and the need for an improved and unified ESA MBSE solution has ultimately led us to broaden our thinking for the next version of the ESA SysML Profile/Toolbox. The proposed presentation will introduce the approach to

MBSE injection in ESA projects and use of MBSE to date, the needs from an MBSE solution, and the evolution from the ESA SysML Profile to a unified ESA MBSE Solution.

A definition process has been created to produce an MBSE language, toolset and methodology, which will be the main components of the ESA MBSE Solution. The process is imagined as a "pipeline" in which the space domain standards, documents or processes are taken as input, and a meta-model and methodology are produced as an output. Finally, these can be implemented in the toolsets to provide a usable solution for end-users.
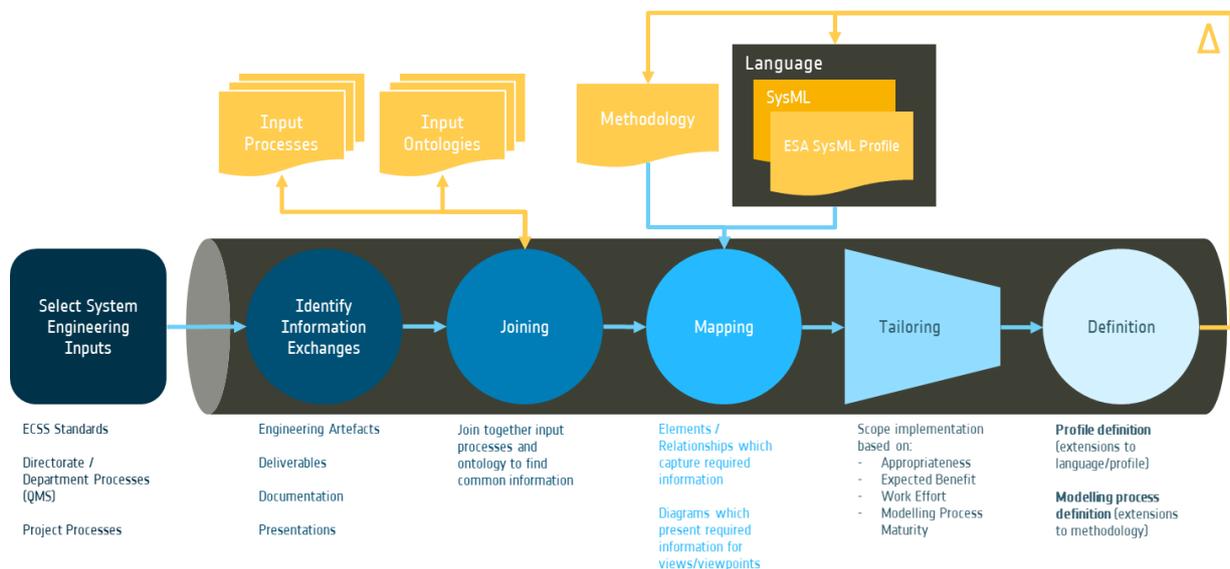

Figure 2 – Proposes "Pipeline" Definition Process

The definition process is explicitly designed to:

1. Enforce rigour and ensure all concepts are well-defined, documented and justified;
2. Ensure compliance to the relevant ECSS standards (e.g. ECSS-E-ST-10C) in terms of system engineering concepts and process;
3. Allow for multiple target languages (e.g. SysML V1, impending SysML V2, Capella);
4. Allow for future expansion and extensibility, such that the solution can be iteratively defined and expanded to include new standards, processes, use cases or integration of domains;
5. Allow for "scoping" of the solution to project needs by identifying the relevant phases and processes.

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In the first iteration of the definition process, the following inputs were taken into account:

- ECSS-E-ST-10C Rev.1
- ECSS-E-ST-10-06C
- ECSS-E-TM-10-25A
- ECSS-S-ST-00-01C

Each of these inputs was analysed in terms of systems engineering process, ontology and information products or documents described in each of them.

From these inputs, a consolidated ESA MBSE methodology and meta-model have been created, and are in the process of being implemented in Cameo Systems Modeler and Enterprise Architect. A preliminary version of the resulting MBSE Framework, giving an overview of the main MBSE layers for the ESA solution, can be seen in (Figure 3 - MBSE Framework).
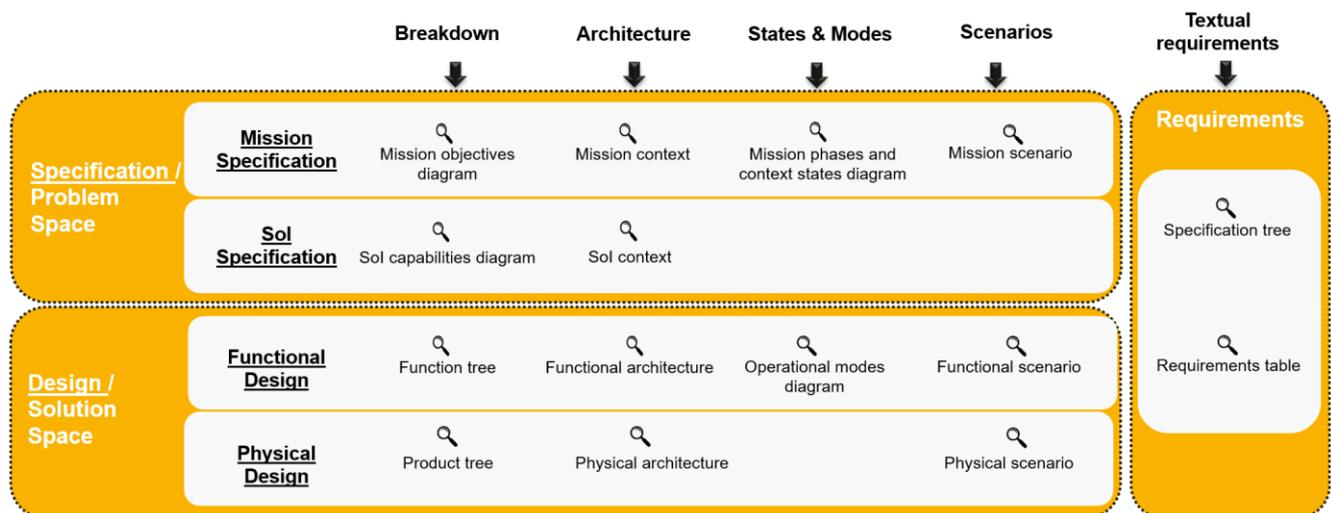

Figure 3 - MBSE Framework

The next steps are:

- The use of the ESA MBSE Solution in projects. Namely, the EL3 (European Large Logistic Lander) mission will be one of the first to make use the new ESA MBSE Solution. This will allow to test the applicability of the current approach and provide some feedback for the new versions.

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- A second iteration of the definition process to incorporate other systems engineering areas such as interfaces management and verification and validation into the ESA MBSE Solution.

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