How MBSE can help AIV domain. A practical approach

N. Salor Moral, RHEA Group, Madrid, Spain
P. Beltrami, RHEA Group, Darmstadt, Germany
Alex Vorobiev, RHEA Group, Diegem, Belgium
Sam Gerené, RHEA Group, Leiden, The Netherlands

Introduction

The application of Model-Based Systems Engineering to manage the growing complexity in system design and development starts at the beginning of a project on the left side of the Systems Engineering V-model by conducting analysis of the problem and the potential concepts on functional and logical level all the way down to specifying the concrete technical solution on physical level. However, little application is currently seen in the space industry to apply MBSE as support for the activities on the rights side of the V-model, i.e. for assembly, integration and testing/verification and validation.

The objective of the Model-Based System Engineering for AIV (MBSE 4 AIV) system, subject of this paper, is to bring the same principles and related benefits to this later project phase activities by creating a single-source of truth for AIV relevant information capture and exchange between different tools for on/off-site AIT test campaigns to avoid manual work and inconsistencies.

The production of a tool suitable for the reporting of AIT and Verification activities using a language understood by all parties is, thus, the final goal of the project.

But how will all parties share the same understanding? And how can the documentation of such understanding be automated? The answer to those questions implies the digitalization of the engineering tasks throughout the lifecycle. Digitalization of the information will allow automation and ensure data persistence while conceptualization will provide interoperability. Both topics are involved within the MBSE domain, which is core to this development and roadmap.

In 2017 a collaborative effort between the Agency and European Large System Integrators (i.e. LSIs), took place to define an ontology focused on the reporting needs for AIT & AIV stages. During this effort, a comparison of the contents of real AIV reports created (mostly manually) and used by the LSIs was performed. It was clearly seen that while different reports shared some commonalities, the required contents of test reports differ significantly across departments and test activities, and none of the inspected test reports achieved a complete coverage of the required content as defined in ECSS-E-ST-10-02C. Furthermore, the LSIs identified missing contents on manually creation which were deemed useful and should be added.

From that analysis the following was drafted:

- requirements for a software reporting system,
- user stories representing the expected features
- a data model named Test Report Standard Ontology (i.e. TRS) [1].

This paper presents the ongoing work for the creation of a conceptual data model able to capture all relevant AIV knowledge and the implementation of a tool to exchange and generate reports compliant with those semantics. From that model, physical schemas will be automatically generated to be used for the digitalization of the involved data and for the definition of exchange interfaces used by the future developed AIV reporting tool which will have to satisfy selected AIV Use Cases.

Use case definitions

For validating a future report generation tool, OHB defined a set of Use Cases explaining the features an AIV report generation tool should provide. Each Use Case specifies how AIV engineers and experts would interact with the tool to request different types of AIV reports by the selection of different parameters and which would be the expected outputs.

In most cases, these reports do not exist yet as currently the information is spread over different document and tools. The definition of the targeted reports has been a huge effort of identifying nice-to-have/desired capabilities instead of replicating current mechanisms (which have not always proven to be efficient).

The identify use cases drafted by OHB involve the following types of reports, status report, verification status report, timeline report, milestone report, procedure summary report, test specification summary report or as run report. The semantics, data dependencies, actors, goals, inter-relationships and expected navigation between them will be described in the paper.

Conceptual data modelling

Parallel to this project, a Space System Ontology (SSO) [2], led by ESA is being modelled. That ontology development is coordinated by the so-called "**O**verall **S**emantic **Mo**delling for **S**ystem **E**ngineering" Governance (OSMoSE) for ensuring semantic interoperability between all partners. As the Object Role Modelling Method (ORM) [3] through the NORMA Tool is being used for the Ontology development, the conceptualization of the AIV Reporting semantics has applied the same methodology and tools to facilitate the future integration of the resulting conceptual data model will be integrated) in the Space System Ontology.

Within the MBSE4AIV, the conceptual modelling exercise was performed in two separate ways to represent and align on one side, the knowledge already captured by the TRS data model on a top-down approach, and on the other, the practical updated needs of the industry which shall be demonstrated with real examples (on a bottom-up manner). These two opposite direction approaches were merged in a single conceptual model via agile meetings with ESA and AIV experts until no more concerns or problems were raised.

Exchange interfaces

In order to ensure that the AIV information can be disseminated between the customer-prime-supplier chain with complete understanding, comprehensive data exchange interface(s) will need to be defined based on the conceptual data model created.

Levels of the exchange interfaces will also be impacted by security constraints and the level of granularity desired and agreed between parties. As a consequence, a generic interface with the minimum conceptually meaningful information (i.e. shallow exchange) has been defined. On top of it, another (i.e. the native one) has also been created to enable complete (i.e. deep) exchange including any referenced data which may belong to another UoD.

The provision of this interfaces will be developed on top of a generic hub (i.e. MBSE Hub) also developed for ESA and European Industry to exchange all space related knowledge. This hub has been designed following a microservice architecture, to which the AIV Interfaces will contribute with dedicated microservices handling and processing the information according to the defined conceptual model and generating the defined reports per identified Use Cases.

Conclusions

The ongoing work performed up has already identified how tight is the relation between the AIV and other space related domains (e.g. OPS, AIT, Functional). On producing a common Hub infrastructure which will allow exchanging and correlating all space information across phases, companies, etc. These interconnections are fundamental to be traced and harmonized so concepts mean the same thing for everybody; otherwise the implementation will fail and the results will not be trusted.

Therefore, there is a need for data harmonisation and a fast iteration cycle for the governance of the different UoD to avoid collisions, misunderstandings or assumptions not captured in the models.

The paper will not only describe the semantics of the AIV domain and its connection with the overall SSO; but also the implementation of the exchange interfaces in the MBSEHub framework and the report generation logic which will make use of all the conceptual knowledge to create the needed reports. The user interface contributions will also be shown as front-end extensions which will display the resulting reports to the final users.

References

[1] Test Report Standard https://indico.esa.int/event/201/contributions/1864/attachments/1599/1846/1000b_Test_Report.pdf

[2] Space System Ontology (SSO) https://mb4se.esa.int/OSMOSE_Space%20System%20Ontology.html

[3] Object Role Modelling (ORM) http://www.orm.net/