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IAA-BR-16-0P-49 A SysML reference model to satellite/launcher interface and its instantiation to a CubeSat Project

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ABSTRACT

Every satellite project needs to take into account all the concerns imposed to its interface to a real launcher vehicle, as it is the main interface of the satellite to the outer world during its launch lifecycle phase. This interface generates constraints that the satellite needs to comply. In this work a Model-Based Systems Engineering (MBSE) approach is taken to define a reference model to this interface which is later on instantiated to a CubeSat mission as a case study. MBSE is an emerging technology that provides many advantages to the classical and document-oriented Systems Engineering (SE) process. One advantage to this approach is solving the integration problem that each one of the individual systems domain disciplines have in the variety of their own well-established modelling methods and tools to support design, analysis, verification and validation. Since these disciplines are not, a priori, well connected, data exchange and sharing may become cumbersome[1]. This is where MBSE comes into place as it primarily models the whole system from a holistic problem point-of-view. MBSE can support tools for early system verification and validation[1] and can provide means to simulate and execute many parts or the whole system. Models are here written in SysML (Systems Modeling Language) which is a general-purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities and can model systems architecture and behavior. Finally, this paper shows how the launcher-satellite interface reference model is effectively used during a launch lifecycle Systems Engineering (SE) process, how it supports many Systems Engineering (SE) processes and how it meets the constraints imposed to a CubeSat project taken as a satellite case study.

OBJECTIVES

- To have a reference MBSE model in SysML for the interface system of a CubeSAT with the launcher during the launch lifecycle phase.
- This model must have all constraints and concerns imposed to the satellite by the launcher
- To show how this model and MBSE approach can support classical SE processes.

DEVELOPMENT

Model-Based Systems Engineering (MBSE) and the SysML language can enable Early V&V cycles through Systems Engineering (SE) processes.

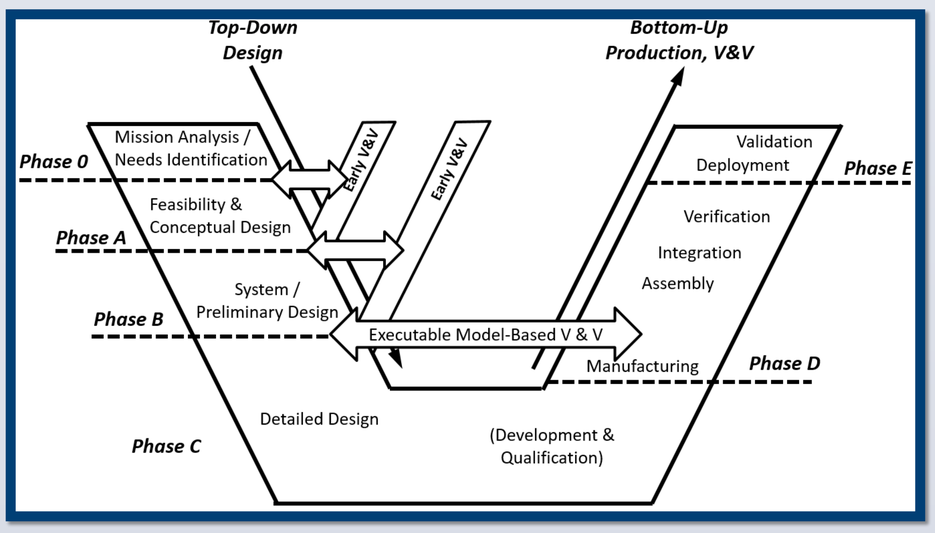
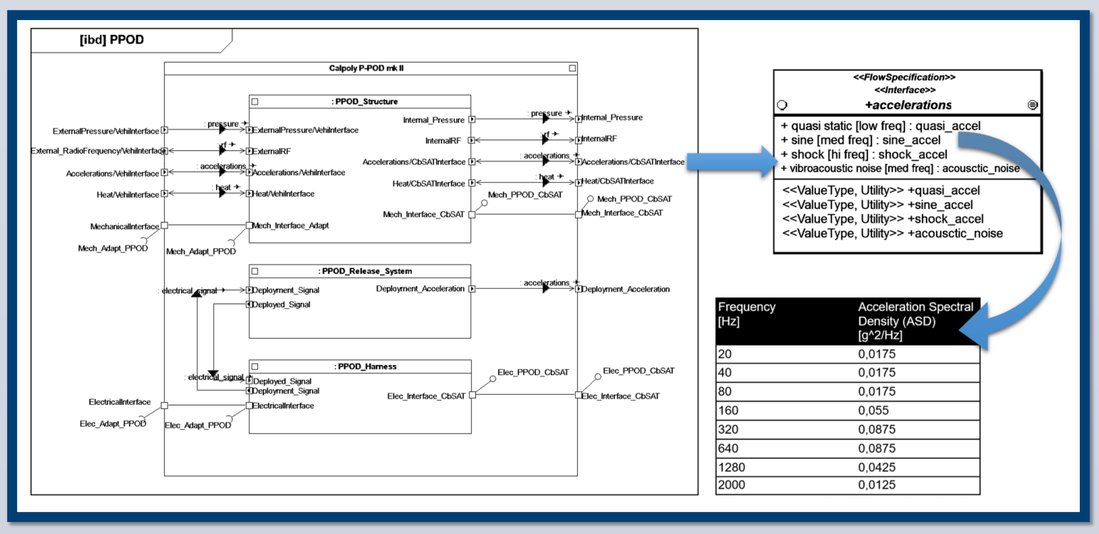


Fig. 1 The systems engineering V-model enhanced with early model-based verification and validation[1]

Flows represents constraints and concerns generators phenomena during the launch lifecycle phase. They can be studied Early



Frequency [Hz]	Acceleration Spectral Density (ASD) [g^2/Hz]
20	0,0175
40	0,0175
80	0,0175
160	0,055
320	0,0875
640	0,0875
1280	0,0425
2000	0,0125

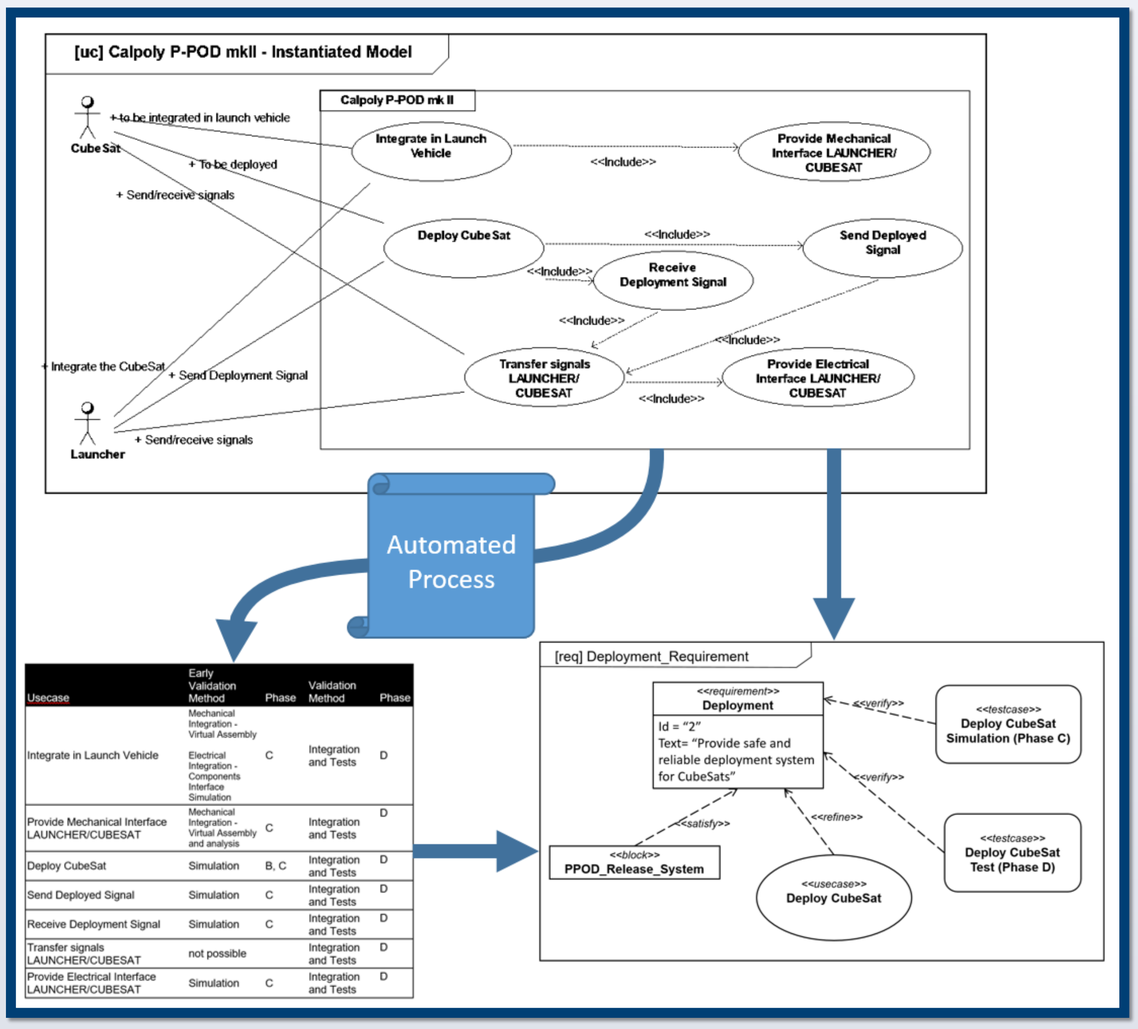
Fig. 2 Flows modeling phenomena through an Systems Engineering Process

Every stakeholder's necessity derives one or more requirements. The system validation means to check if the system meets all stakeholders' necessities. The system must meet all requirements to meet all stakeholders' necessities.

It is important to verify if the system is meeting every requirement, to do so one must choose V&V methods.

A verification has its own necessities, for example, for a test we must have the system to be tested and the test procedure, for a simulation we must have the model, the software and the data involved.

As the model is supposed to have all relations of a requirement, this model supports programmatic, project schedule and data sharing.



Usecase	Early Validation Method	Phase	Validation Method	Phase
Integrate in Launch Vehicle	Mechanical Integration - Virtual Assembly Electrical Integration - Components Interface Simulation	C	Integration and Tests	D
Provide Mechanical Interface LAUNCHER/CUBESAT	Mechanical Integration - Virtual Assembly and analysis	C	Integration and Tests	D
Deploy CubeSat	Simulation	B, C	Integration and Tests	D
Send Deployed Signal	Simulation	C	Integration and Tests	D
Receive Deployment Signal	Simulation	C	Integration and Tests	D
Transfer signals LAUNCHER/CUBESAT	not possible		Integration and Tests	D
Provide Electrical Interface LAUNCHER/CUBESAT	Simulation	C	Integration and Tests	D

Fig. 3 Requirement refinement, verification and validation (V&V) and early V&V supported by MBSE

CONCLUSIONS

Dealing with systems´ complexity demands sometimes rigorous and formalized SE practices and space systems are a natural candidate due to the complexities it has to deal with. This work glimpsed how a MBSE approach for SE processes is capable to discover, to describe, to record and deal with some concerns and constraints of the satellite/launcher interface.

A CubeSat project was taken as a case study since these projects are always executed by different discipline students, and by different institutes. In this case, a MBSE approach is needed as an effective approach in terms of data recording and sharing.

In order to take advantage of MBSE all project participants must share a consistent model. The MBSE approach is not only based on the model itself, but it is based on the MBSE processes, tools that implement it, the necessary infrastructure and people. Therefore, a simple reference model to the underlying interface problem was presented as a basis for MBSE approach implementation especially on modeling some project concerns and constraint as well as standardizing data exchanges between tools and people.

Future work will focus in two aspects: (1) The models presented still need refinements and (2) Proper metrics for evaluating effectiveness.

REFERENCES

[1] H. Peter de Koning, H. Eisenmann, M. Bandecchi, *Evolving Standardization Supporting Model Based Systems Engineering*, 2010, SECESA Conference Lausanne, Swiss, p. 17.-19.

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