> The benefits of MBSE are also closely related to the selected scope and level of detail of the model. Do you have any findings / lessons learned how to choose what to model and where to stop?

We see mainly 3 levels of implementation of SysML, each with an added benefit.

1. COMMOM WORK METHODOLOGY & FLUID COMMUNICATION. This can be obtained using SysML Requirements and Behavioural diagrams (Use Case, Activity Diagrams and state diagrams) and requires little effort to learn and implement.
2. UNIQUE DESIGN REPOSITORY & CLEAR ICD. This requires the integration of structural diagram (without parametric diagrams). Includes the Product Tree and all the intefaces. The immediate payback benefit is on the ICD. Requires more effort in particular in the setup of the project infrastructure.
3. AUTOMATIZATION & BUDGET. This requires the use of parametric diagram and a deep effort in the modelization.

According to SENER experience, not all projects require all 3 levels, but all projects can already get benefit from the first level. Going to the last level is a company decision and depends on the complexity of the project, the size of the team and the future reuse perspective.

We presented the lessons learned last year in the paper "MBSE2020 - Lessons learned from the use of SysML in Space Systems at SENER Aeroespacial"

> You had mentioned that training material to learn SySml is limited. From your experience can you point to some resources to master SysMl for a beginner. Thank you

The documentation on SysML can be helpful to understand the different types of diagrams and elements that are part of this language. However, we find it a bit technical. But then, it is important to know how to use the selected MBSE tool and the available training material is intended for advanced level or specific topics. This is the reason why we prepared training material for beginners to deliver to all the engineers in our project.

For SysML beginners we found the following reference very useful:

SysML Distilled : A Brief Guide to the Systems Modeling Language. ISBN10 0321927869, ISBN13 9780321927866

And, since we are working with IBM Rhapsody, the HARMONY-SE Deskbook:

"Systems Engineering Best Practices with the Rational Solution for Systems and Software Engineering Deskbook Release 3.1.2" (Deskbook), released February 21, 2010.

> What would you recommend to another company considering adopting MBSE?

Buy 2-3 floating tool licenses and try it. SysML cannot be learned/implemented without a tool. One of the most critical decision is the selection of the Tool. Interoperability and data exchange among different tools according to our experience is very poor.

SysML opensource tools are also not a good option so the decision is if to invest on Cameo, Enterprise Architect or IBM Rhapsody. This may depend not only on the costs but also on the customers you have.

>How do you manage exchange of MBSE data between all the engineers working on the project?

We have one model that contains all the design data in the project, so all the engineers can access to it. Moreover, we are integrating the IBM Rhapsody SysML tool with another IMB application (Engineering Workflow Manager) that allow to perform change and configuration management actions and enable concurrent working on the model at the same time.

>Excellent presentation, I am curious understand why the choice was made to move to MBSE? Was this to complete an objective?

Thank you very much.

The main reason to adopt SysML for the ETPACK project was the limited budget available to maintain documents. Since the design of the mission required frequent changes, we found SysML helpful to update the model easily and reduce inconsistencies.

We can also reduce the times for data exchange between engineers because the data is available for all in the SysML model.

We presented the lessons learned from the company perspective last year in the paper "MBSE2020 - Lessons learned from the use of SysML in Space Systems at SENER Aeroespacial". You can consider to read it if you are interested.

>It was mentioned that the challenges using MBSE/SysML were huge. Could you elaborate more on the benefits, possibly "measurable" benefits?

The main benefit is to save money by working more efficiently. Indeed we made in the past an exercise of the quantification of the benefit of using MBSE in term of engineering hours saving. We came out with a complex formula having as variable the number of requirements, the number of team member, the number of subcontractors.

In order to simplify, if you assume that a well managed project requires about 30% of "re-engineering" hours due to refinements of design errors not spot at the beginning, adoption of MBSE should allow a 20-30% saving of that time resulting in an overall 6-9%. This means that for a 10.000h project, using MBSE your company could save from 600 to 900 hours.

>Would the produced Rhapsody model or the metamodel behind it be available?

We have currently an activity running with ESA on this topic and we are planning to deliver the adapted ESA Profile at the end of the work.