EasyMOD
Executive Summary Report

Abstract

The EasyMOD project takes place in the OSIP Model-Based System Engineering Campaign as an Early technology Development of ESA, as well as an IRT Saint Exupéry project funded by Airbus Defence and Space, Airbus Commercial Aircraft, HDGroup and the French Government. It aims at improving the human/machine interactions in the use of MBSE models, by providing friendlier visualisation and review capabilities, modelling assistants and new kind of HW and SW interfaces. It is the follow-up of the BabyMOD project, which aimed at providing a small Proof-Of-Concept of some EasyMOD foreseen capabilities.
Using the proof-of-concept tool named EasyMOD, it is possible to create review projects of heterogenous MBSE models (Cameo and Capella) on several kinds of structural analyses (Product Breakdown Structure, Mass analysis, Power Consumption analysis, Functional Breakdown Structure, Functional Flows...) in an homogeneous way.

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1 Introduction

1.1 Problem statement

There is an increasing interest in space industry for the use of model-based approaches as a mean to support system requirements definition, perform system analysis and architecture tradeoff. Usual tools such as Cameo Systems Modeler, Capella, or Enterprise Architect, are foreseen. Therefore, in the future, the overall review board will have to provide a Review Procedure and its associated data-package that contains such models to review. However, assessing the data-package completeness, preparing the review procedure and performing the review could be challenging, especially when the actors are not Model-Based Systems Engineering (MBSE) experts. The challenges we plan to address are summarized as follows:

- **C1 Modelling Languages** Knowledge: Modelling languages provide many concepts, which allows the detailed modelling of the system. However, those languages are not necessary known by the actors.
- **C2 Hidden Information**: Scaled system engineering models may contains lot of elements and links that are laid out within complex model structures. Navigating in a model, for which many diagrams have been created for different purposes, is difficult for other persons than the model author.
- **C3 Abstraction Level**: Abstract models are quite used to manage system complexity and to provide solution free architectures for early architecture design and trade-off. However, for non MBSE experts, abstract models are hard to review since they are not necessary represented with concrete symbols.

1.2 Project summary

A global methodology aiming at solving the problem of reviewing MBSE data, with focus on the previously stated challenges, was developed thanks to assets brought by IRT Saint Exupéry from previous projects, named TeePee and BabyMOD.

The first step of the project was to capture ESA’s needs on review of SE data. Thanks to that, it is possible to go to the next step that will propose a process that will clarify the role of each participant in this review process, what are the expected reviewed data, when are they reviewed, how it is linked to configuration management.

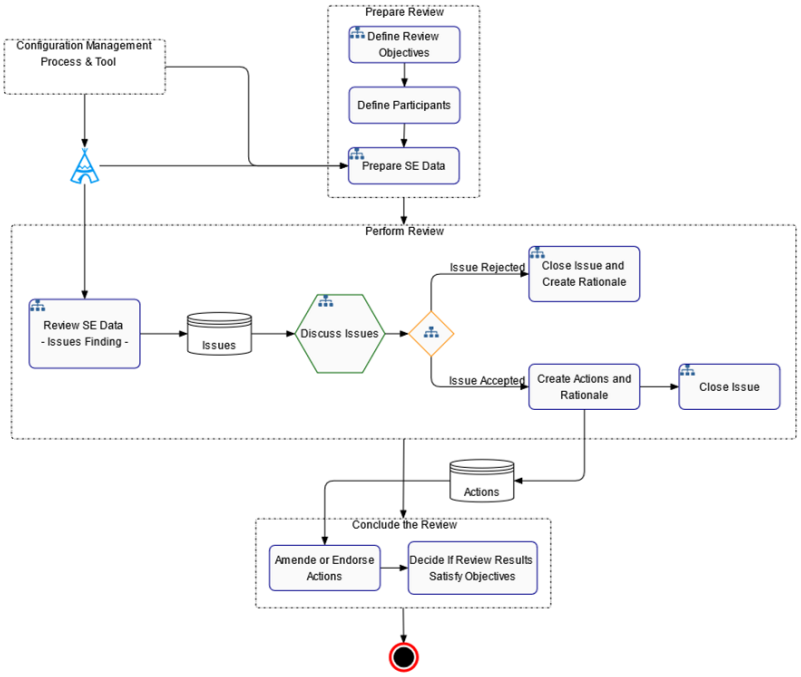

Figure 1 : Review Process at ESA

Then, the specification of a demonstrator taking into account IRT Saint Exupéry's assets from previous projects (BabyMOD, MOISE, TeePee4Space). Last, software development is required to fulfil users' needs. Documentation on EasyMOD demonstrator at user and developer levels is provided to enable ESA engineers to use EasyMOD on their own.

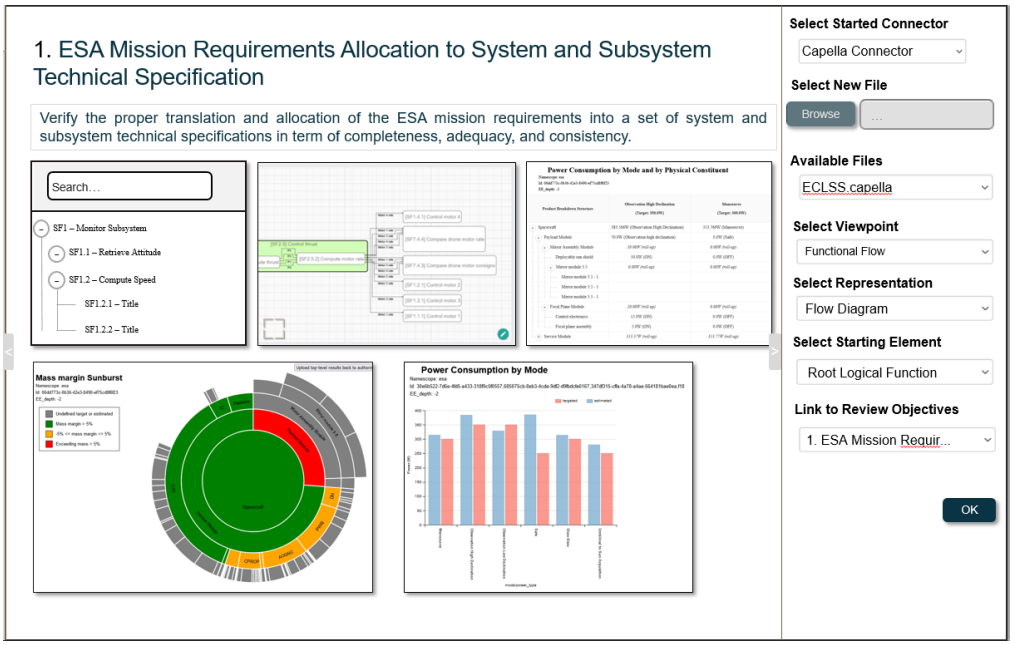

Figure 2 – Specification of the Human-Man Interface (HMI)

By the end of the project, we have demonstrated the relevancy of the proposed methodology and its implementation in EasyMOD for the review use case.

2 Proposed methodology

In this section, we describe our solution to support the review of MBSE data.

2.1 Building a shared vocabulary

Since authoring tools (such as Cameo, Capella, or COMET in the ESA CDF context) relies on heterogeneous methods and languages, a shared vocabulary could be useful to review those models in a homogenous way. Hence, we propose to rely on a common vocabulary formalized as a pivot meta-model to ensure the review of heterogeneous data.

Instead of trying to provide an exhaustive mapping with the concepts of the various modeling languages, we propose to define viewpoints dedicated to a given analysis, for which only the modeling artifacts required and agreed between the stakeholders are considered. To complete the mutual understanding, stakeholders shall also discuss and agree the graphical representation via glyph, colors, layout, etc. to share a common mind-set on SE analysis results.

This approach is the one already engaged by ESA in the OsMOSE initiative presented at the ESA MBSE2021 conference[1].

During the EasyMOD project, we used those viewpoints:

- **Function Breakdown Structure** (FBS),
- **Functional data flows** (FDF), as the inputs and outputs of each functions,
- **Product Breakdown Structure** (PBS),
- **FBS to PBS allocation**¸ as the allocation of functions to components,
- **Mass margin**, based on the PBS (PMM) : each component has three parameters attached:
  - A targeted mass, which represent the Top-Down allocation of mass at each level of the PBS in order to meet the high level requirement,
  - An estimated mass, which represent the Bottom-up view of masses actually achieved at each level of the PBS,
  - A mass margin, which is computed as the difference between the targeted mass and the estimated mass,
- **Power Consumption Mode** (PCM): each Component has two parameters attached to each Power Mode:
  - A targeted maximum power, which represent the Top-Down allocation of the maximum power at each level of the PBS for a given Power mode in order to meet the high level requirement,
  - An estimated mass, which represent the Bottom-up view of the maximum power actually achieved at each level of the PBS in a given Power mode.

2.2 Preparing the review

The proposed approach allows the Review Secretary to prepare the review of MBSE models through the following scenarios:

1) Authenticate as a Review Facilitator,

[1] Model Based Space Systems and Software Engineering ~ MBSE2021 (29-30 septembre 2021) · Indico at ESA / ESTEC (Indico)

2) Create a Review project,
3) Load an existing Review project,
4) Edit the Review plan through Review objectives,
5) Insert MBSE data into the Review objectives.

Hereafter is one example for the insertion of MBSE data into Review Objectives as a sequence diagram from a Capella model.

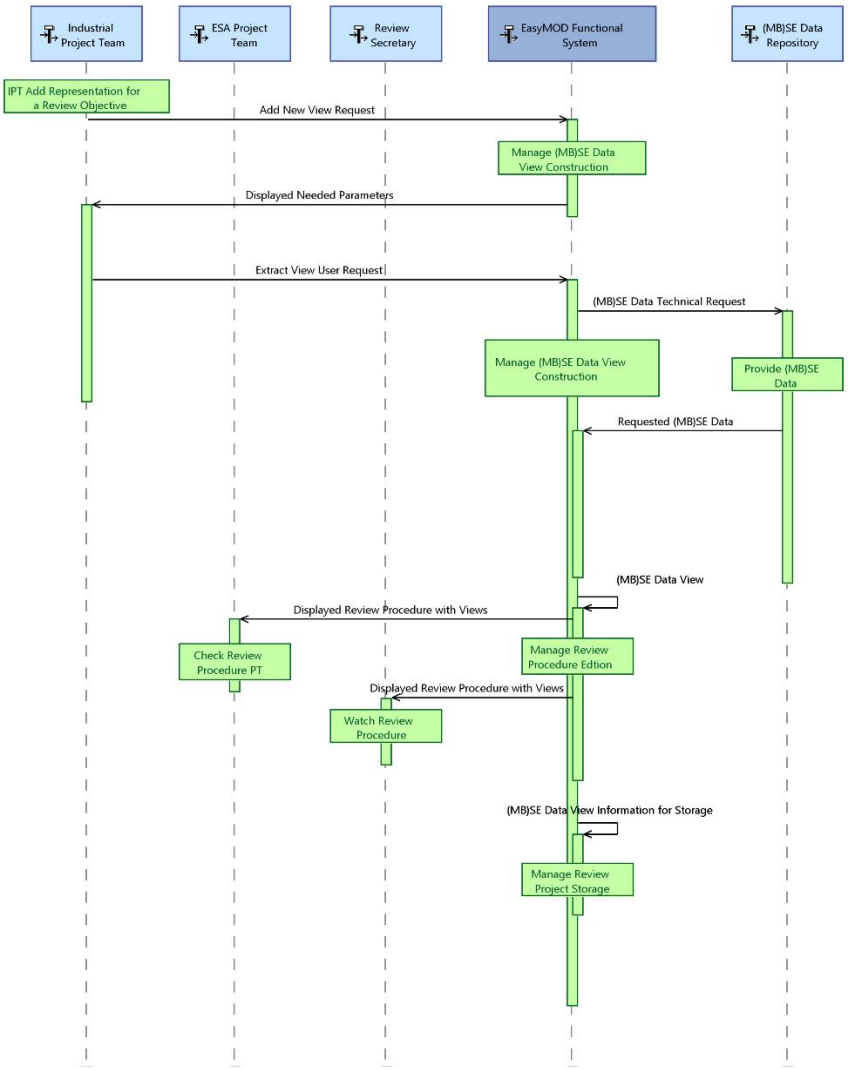

Figure 3 – Scenario for inserting MBSE data into the review project

2.3 Performing the review

Thanks to the preparation of the review made by the Review Secretary, Reviewers should be able to focus on the only important task of their work, which is to provide comments on the model realized to achieve some objectives.

The important topics captured during the project on comments were:

- Granularity: it should be possible to comment either the entire objective, the model elements created to fulfil an objective, some model elements, or a single model element,

- Lifecycle: a comment is created for a given version of a model and could be applicable or not to the next version. Knowing the status of a comment is similar to a change request: is it still valid, on which version has it been taken into account…
- Link to model: using an abstraction has many advantages but raises the question about how the Review Secretary and model author should interact to take into account those comments.

While the first one was partially addressed thanks to the features of the first prototype, the other ones were left apart as similar features already exist in commercial tools.

3 Proof of concept and results

3.1 EasyMOD concepts and architecture

The views extraction feature is implemented within the EasyMOD Proof-of-Concept software by TeePee. This feature permits to extract (MB)SE Data and to represent them as diagrams, tables, or charts. The resulting views are integrated within a Review Procedure thanks to required parameters:

- Data store selection: the (MB)SE Data Repository containing the needed (MB)SE Data to review.
- Viewpoint selection: the viewpoint (according ISO 42010) formalizing the set and types of data needed to create a view, e.g., functional data flow viewpoint, mass viewpoint, or power consumption viewpoint.
- Starting point: the root element from which the view shall be extracted.
- Needed representation: a viewpoint may be rendered using several representations (diagram, tabular, charts ...).

As depicted by the Figure 4, the EasyMOD software is divided into two main components. First, the *EasyMOD Front End* component acquires user inputs and displays the GUI to manage Review Projects, to construct the Review Procedure and to extract and render views inside the Review Procedure. Second, the *EasyMOD Back End* is responsible for the data storage (*Review Project DB*), for requesting MBSE data from repositories, and for transforming raw MBSE data into the right format for the front-end's rendering function (*Back End Service Provider*). The *Back End Proxy* makes the front-end independent from the back-end.

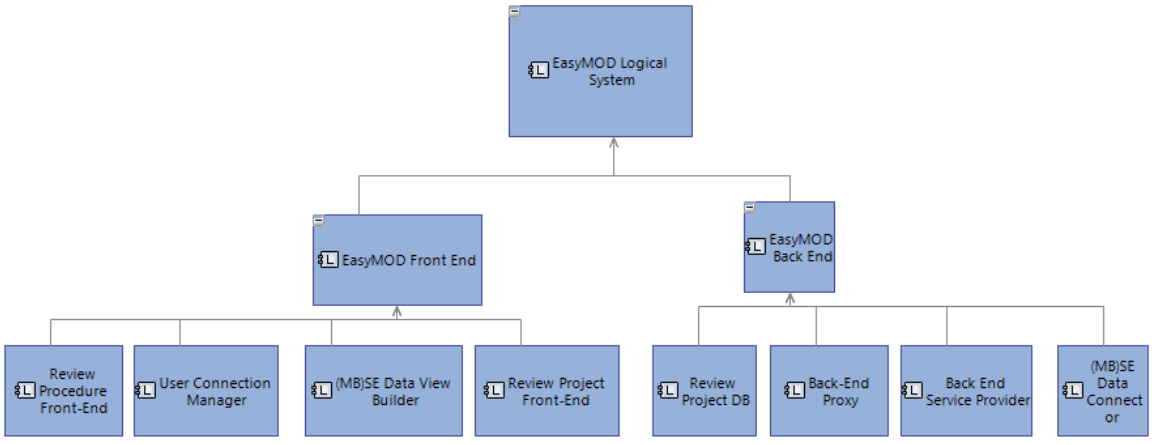

Figure 4 - EasyMOD Logical Breakdown Structure

3.2 Analysis results

During the project, we applied the methodology on the AIDA (Aircraft Inspection by Drone Assistant) case study, developed by IRT Saint-Exupery and open sourced under creative common license (BY-SA 4.0). It is available at this address: https://sahara.irt-saintexupery.com/AIDA/AIDAArchitecture

When connected as a Review Facilitator, you have access to the EasyMOD main HMI consisting of, from left to right:

- a table of content that lists the review objectives,
- the review procedure editor containing a text editor and the capability to add views,
- the commenting system to see comments on views and texts if reviewers already did some work.

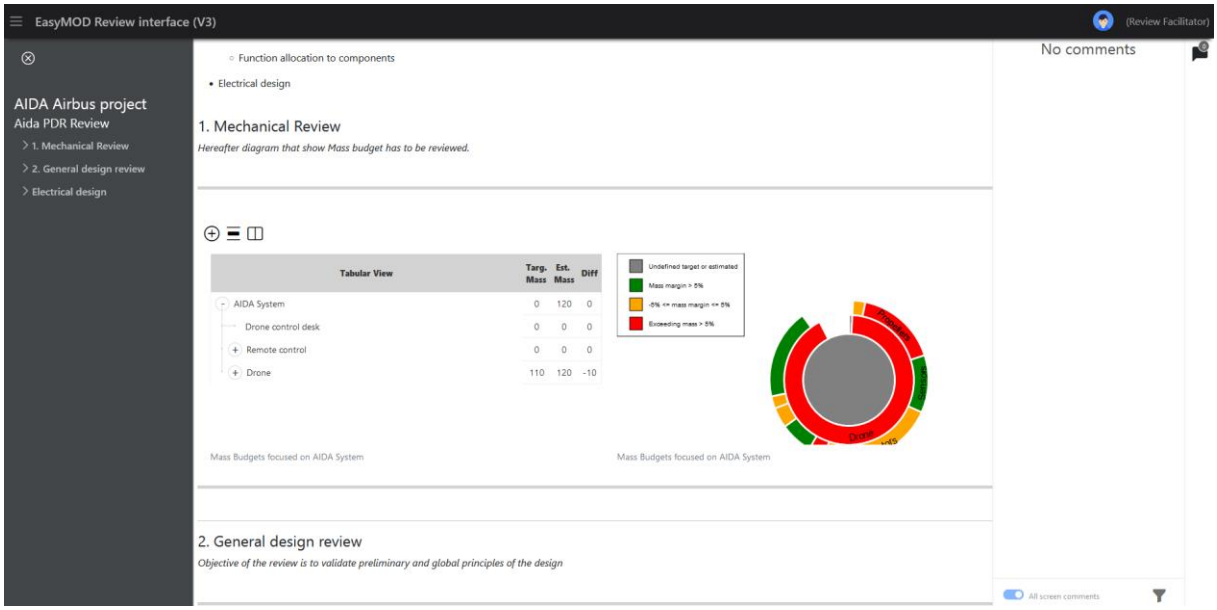

Figure 5 – EasyMOD HMI for the Review Facilitator role

The review facilitator can edit the project description and create review objective within the review procedure. The HMI contains all the tools to add interactive views, add texts, and perform layout of the views within the review procedure document (Figure 6).

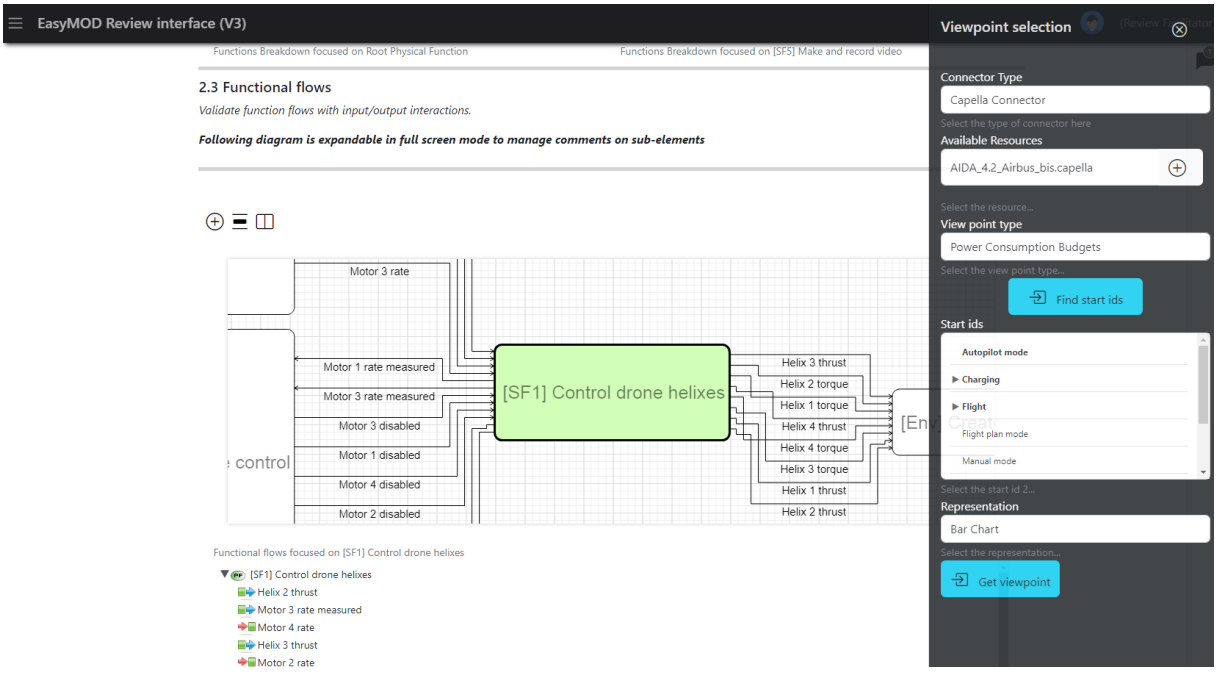

Figure 6 – Viewpoint Selection panel for the Review Facilitator

If the end-user is a reviewer, then the HMI is updated to remove the ability to edit the review procedure but add the commenting system to manage comments on views and texts.

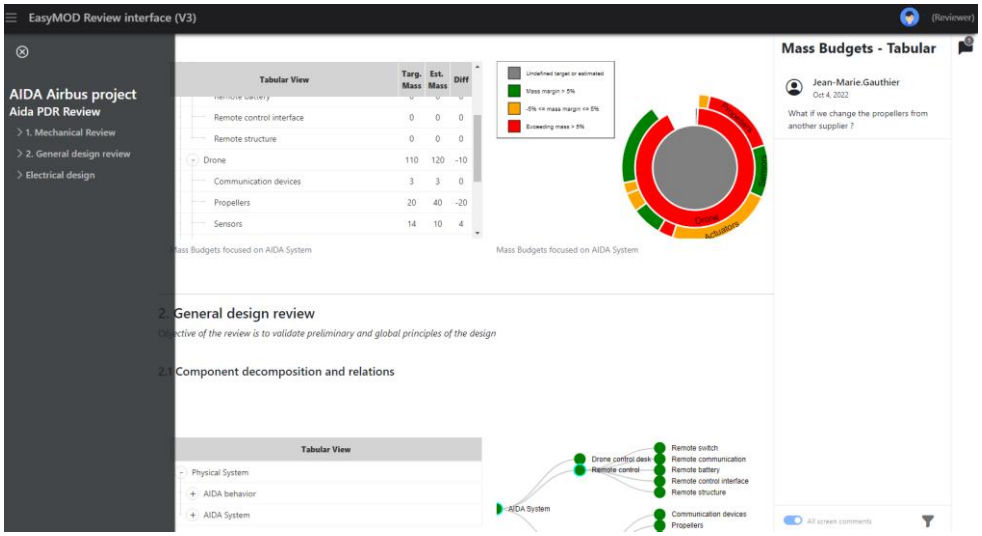

Figure 7 – EasyMOD's HMI for the Reviewer role

A specific behaviour, inherited from the BabyMOD project, was implemented to assess graphical and vocal comments on the functional flows viewpoint. The Figure 8 illustrates this dedicated HMI.

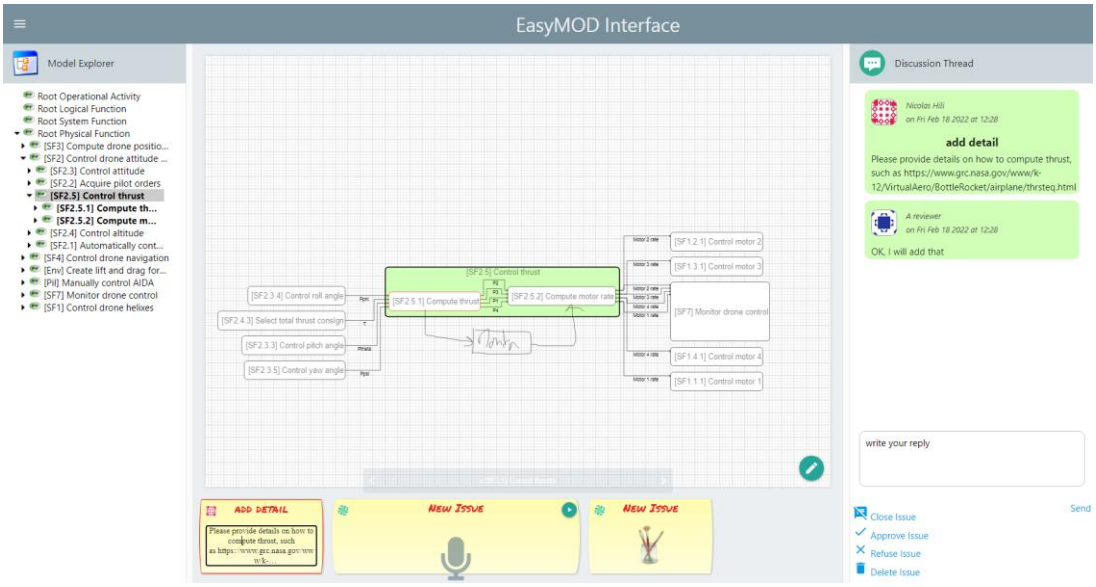

Figure 8 - EasyMOD MS-2 Integration when opening a functional flow in full screen

One important feature of the demonstrator is the use of viewpoints to abstract the data from the MBSE model and represent them in a friendly way to users. Therefore, diagrams are automatically generated from the data contained within the MBSE model but does not use the diagrams created through the authoring tool. Hereafter are some viewpoints and their representations, including the Power Consumption by Mode which was a result from the TeePee4Space OSIP project.

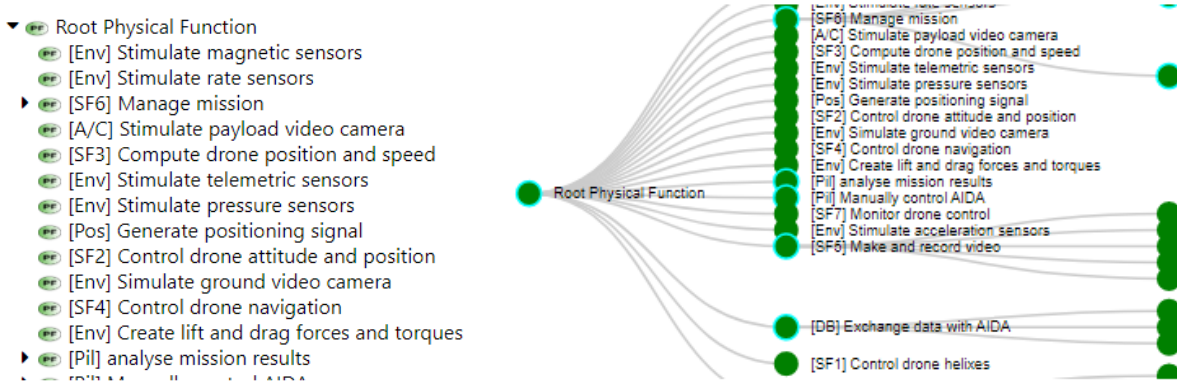

Figure 9 - Breakdown viewpoint with two tree representations

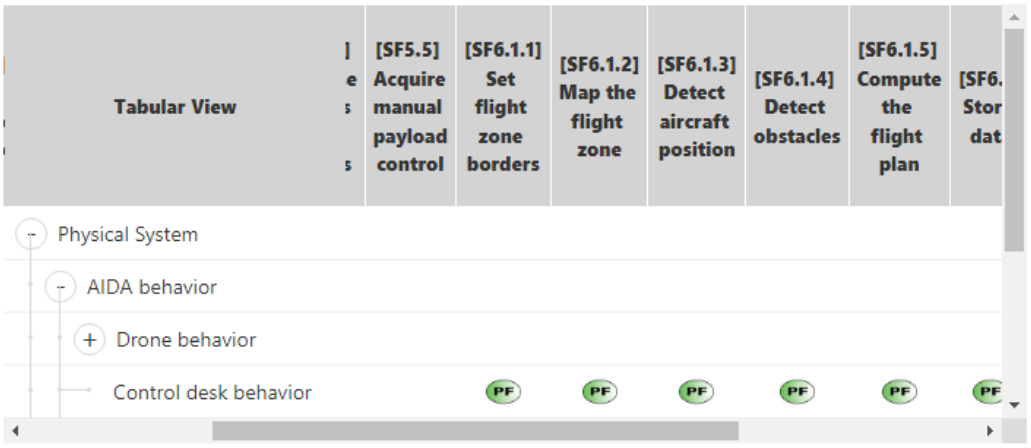

Figure 10 – Allocation viewpoint as a tabular representation

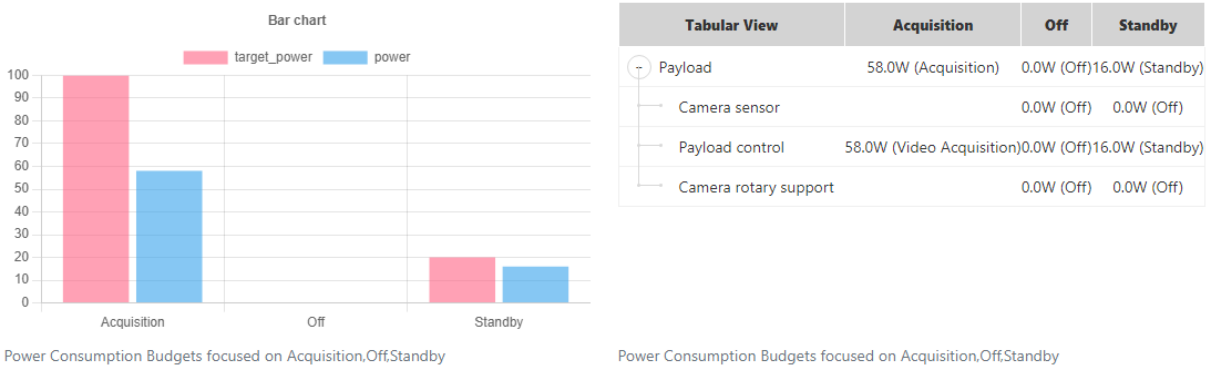

Figure 11 - Power Consumption by Mode viewpoint as barchar or tabular representation

4 Conclusion and perspectives

This experiment has shown an example of the usage of EasyMOD in the context of a review of MBSE models. It is now possible, as a Review Facilitator, to prepare a review thanks to the creation of review objectives composed of text and interactive diagrams. Those interactive diagrams correspond to different representation of various viewpoints of one or many MBSE models, selected by the Review Facilitator as a good entry point to fulfil the review objective. Then, multiple reviewers can access the Review Objectives prepared by the Review Facilitator in order to comment the proposed elements. Those comments can be textual or, for the Functional Flows viewpoint, graphical and vocal. Furthermore, a discussion between all stakeholders of the review can occur on each comment.

This achievement opens some perspectives for the future. One perspective would be to take advantage of the OSMOSE initiative which aims at defining a Space System Ontology. Indeed, as TeePee relies on the concept of viewpoints for which a simple data model is defined and agreed between stakeholders, such an ontology would be very relevant to be implemented as a more complete data model in TeePee.

In addition, the views extraction and their layout within a web page is not only useful for reviews. Indeed, this feature establishes the basis for leveraging MBSE data visualization. It would be possible to use this feature to provide a dedicated MBSE dashboard system (like Kibana[2]) or a decision cockpit. In addition, it would be interesting to investigate the exploration of MBSE data by dynamically creating views from other views on user request.

The view extraction feature could be used as an opportunity to investigate research questions about the MBSE data representations itself. For instances, what are the best representations for the logical data flow viewpoint? What kind of dynamic filter could be applied for a specific concern? How to visualize several layers at a time without being lost in the complexity of the diagrams, or without losing the context of the current task?

It would be also interesting to integrate personal assistant and model authoring within such a tool to provide an ‘easy to use” application for modelling and impact analysis in a model based specification.

Other axes for the development of EasyMOD could be:

- The integration of the model aggregation principles of TeePee with the model review concepts defined in the EasyMOD OSIP project, in order to enable the review of unified aggregated models,
- Taking advantages of the capacities of TeePee to aggregate data from heterogeneous models to allow the comparison and the consistency management of different views on a system (ex: safety, simulation…),
- Explore other use cases such as the edition of a MBSE model thanks to those new visualizations,
- Explore use cases from other life cycles such as Request for Quotation phases or Operation to build a digital twin thanks to collected data,
- Industrialize the software thanks to a tool editor.

[2] https://www.elastic.co/fr/kibana/