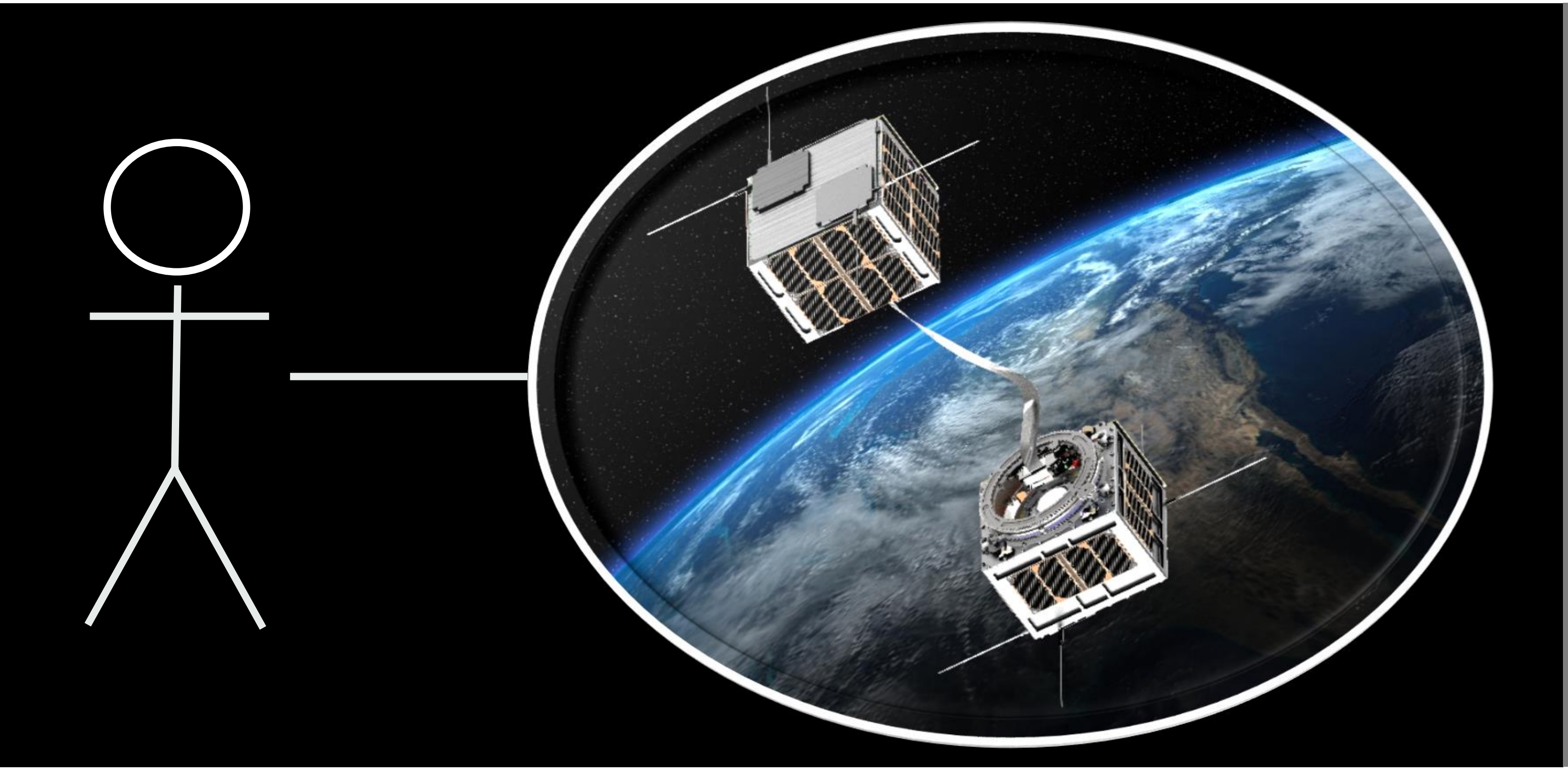
Aeroespacial

28 September 2021



Lorenzo Tarabini Castellani
Sofia Orte Arribas

Deorbit Kit Design with SysML ESA profile

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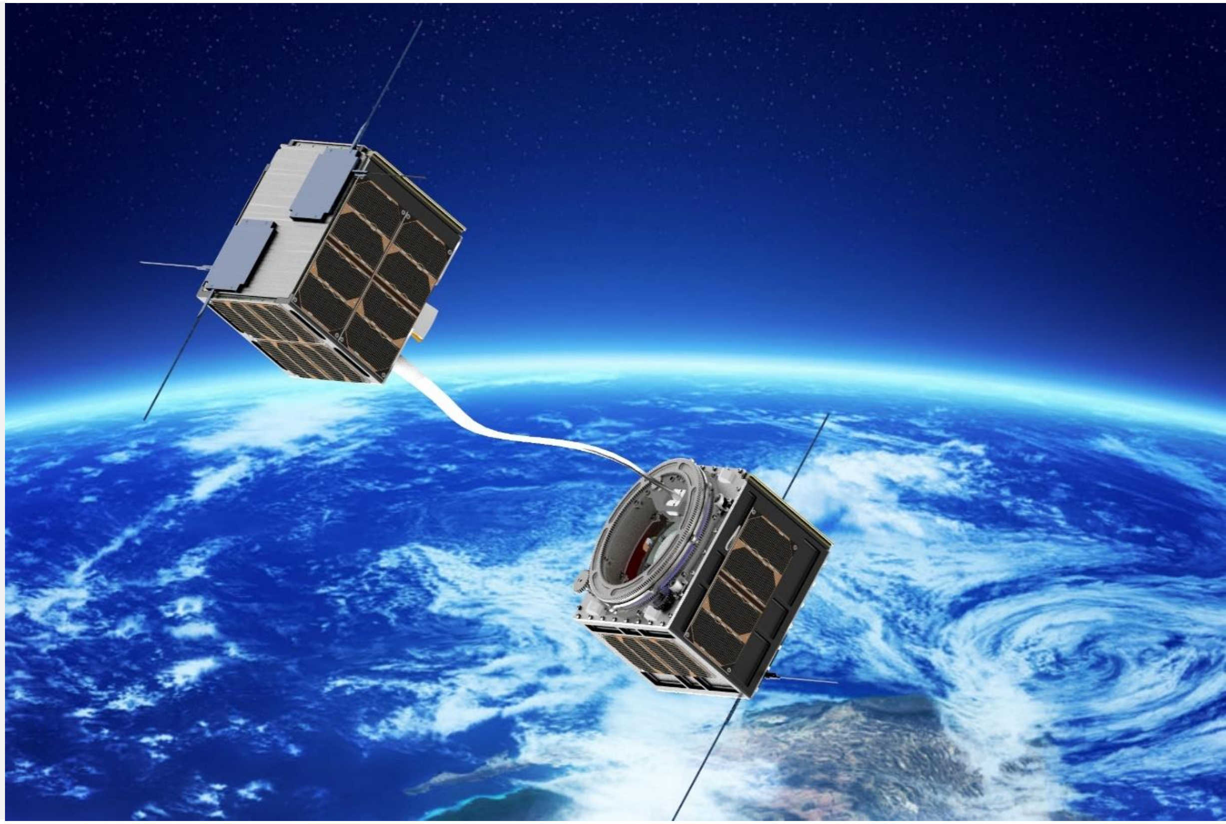
1. Introduction

1. Introduction

E.T. PACK

SENER Aeroespacial is designing a **Deorbit Kit Demonstrator (DKD) mission**. This activity is currently financed with 3M€ by the European Commission **under the FET-OPEN project Electrodynamic Tether technology for Passive Consumable-less deorbit Kit (E.T.PACK).** The objective of the E.T.PACK project is to develop the deorbit kit up to TRL4.

E.T.PACK involves the University Carlos III of Madrid (coordinator), the University of Padova (tether deployment simulations), the University of Dresden (electron emitter) and ATD and IKTS (new material developments).



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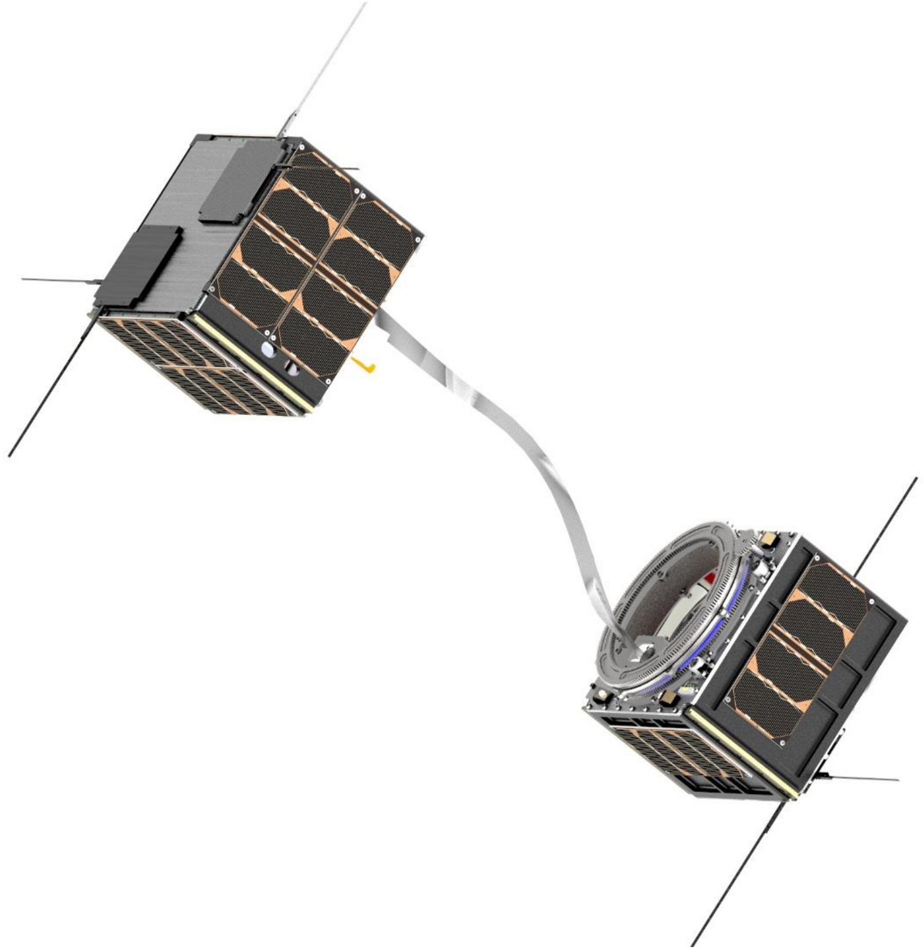
1. Introduction
DKD Mission

The DKD mission consists of **2 spacecrafts packed in a standard 12U/24kg envelope.**

DKD will be launched on a 600 km circular orbit with 51.5º inclination.

After deployment from the launcher, the spacecraft will stabilize its attitude and separate into two modules connected by 500 m of tether. The tether will be a tape of 2.5 cm width and 40micron thickness formed by a conductive aluminum tape, a PEEK segment and an insulated segment.

The **objective of the demonstration is to deorbit in less than 100 days**, whereas the natural deorbit time would be of about 15 years.



1. Introduction

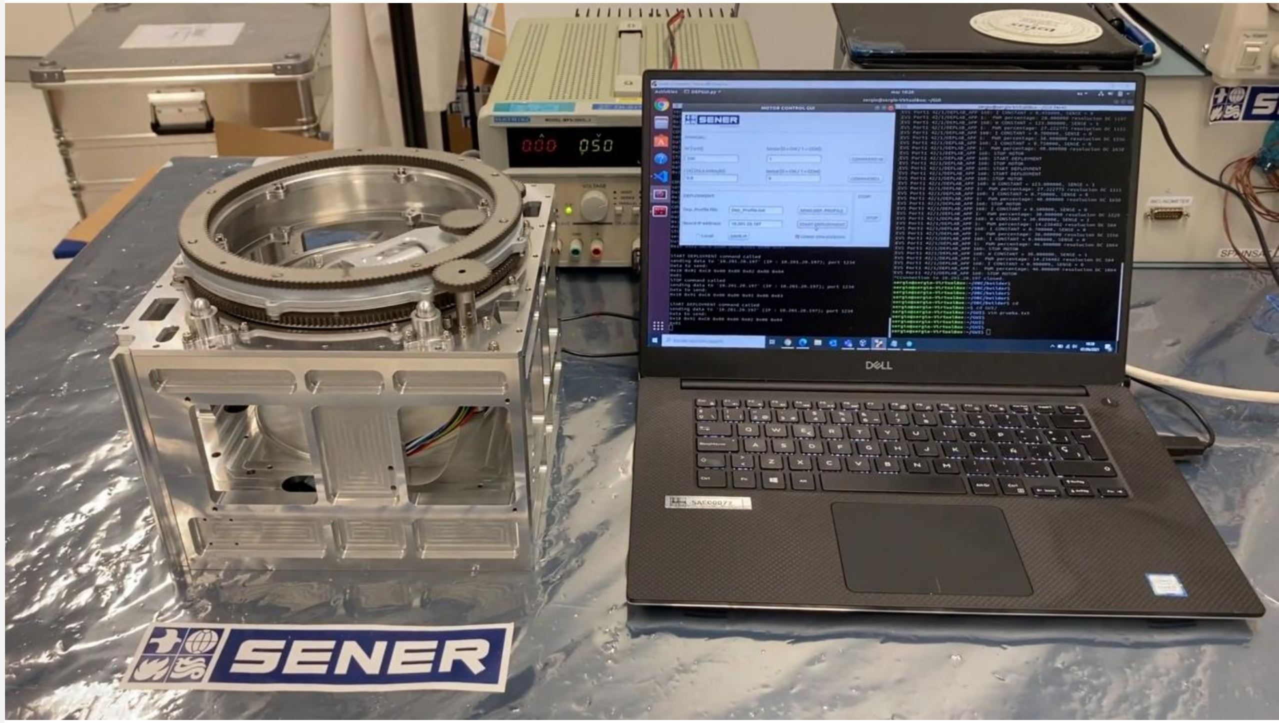
Current Status

The consortium is currently **manufacturing a fully representative satellite model** for demonstrating the critical mission technologies.

Each edge of the tether includes an independent satellite with its avionics and communication system.

For the prototype, a powerful System On Chip based onboard computer using proprietary software is used to control CubeSat radiation tolerant components.

All avionics elements have been procured and are currently under integration, while the structure of the satellite is under manufacturing.



2. Needs

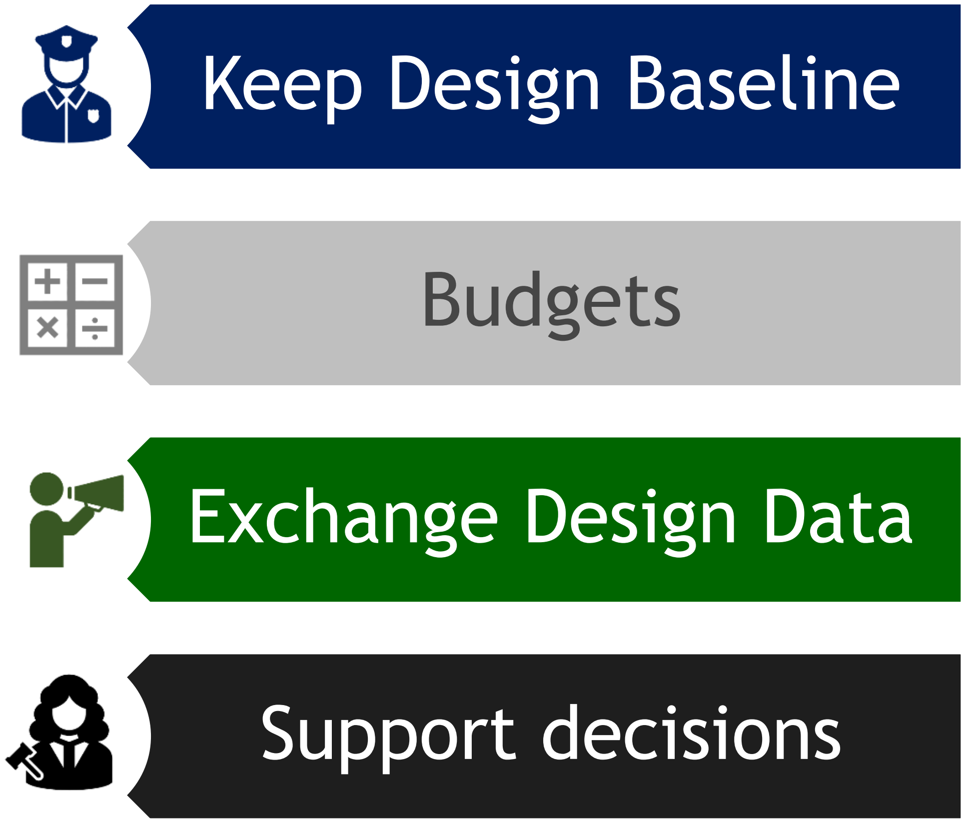
reqPkg
reqPkg contains system level requirements
modelPkg
modelPkg package contains the Product Tree
AITpkg
AITpkg contains the main DK BreadBoard Assemply Integration and Test Sequence
budgetPkg
budgetPkg contains the system budgets including, mass, power, thermal, performances, etc.

2. Needs

Complex system data management

Early in the project it was identified the need to:

- Maintain the design **information updated**
- Establish and keep the **mission budgets**
- **Exchange** efficiently the baseline design data **among the different institutions**
- Ensure **rapid decision making** during the development of the project.



2. Needs
Tool selection

The first design information exchange was based on documentation that soon demonstrated to require frequent updates.

Limited budget was available for maintaining documentation and therefore **SysML language** was selected to model the Deorbit Kit Demonstrator mission.

IBM Rational Rhapsody was selected as the SysML tool. The decision was based on the availability of the tool, modeling skills in SENER and the possibility for universities to access to the licenses.

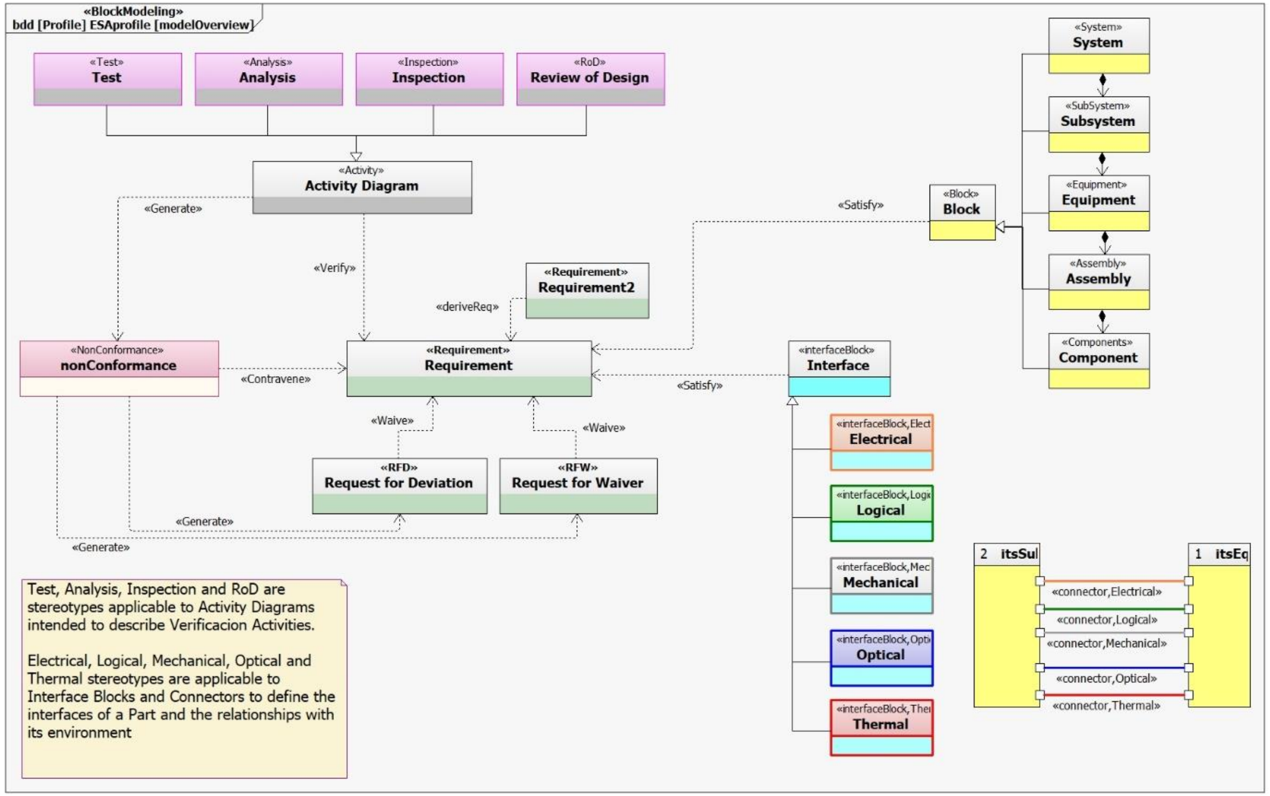
3. ESA Profile

3. ESA Profile

SysML language tailoring was considered necessary in order to design and maintain a consistent and simple space system model among a large multicultural team.

ESA has **created a customized profile** to reduce the generic nature of the language by defining new elements and stereotypes and adopting a color code.

The ETPACK team has **adopted the ESA profile** to model the DKD mission in the frame of the E.T.PACK project.



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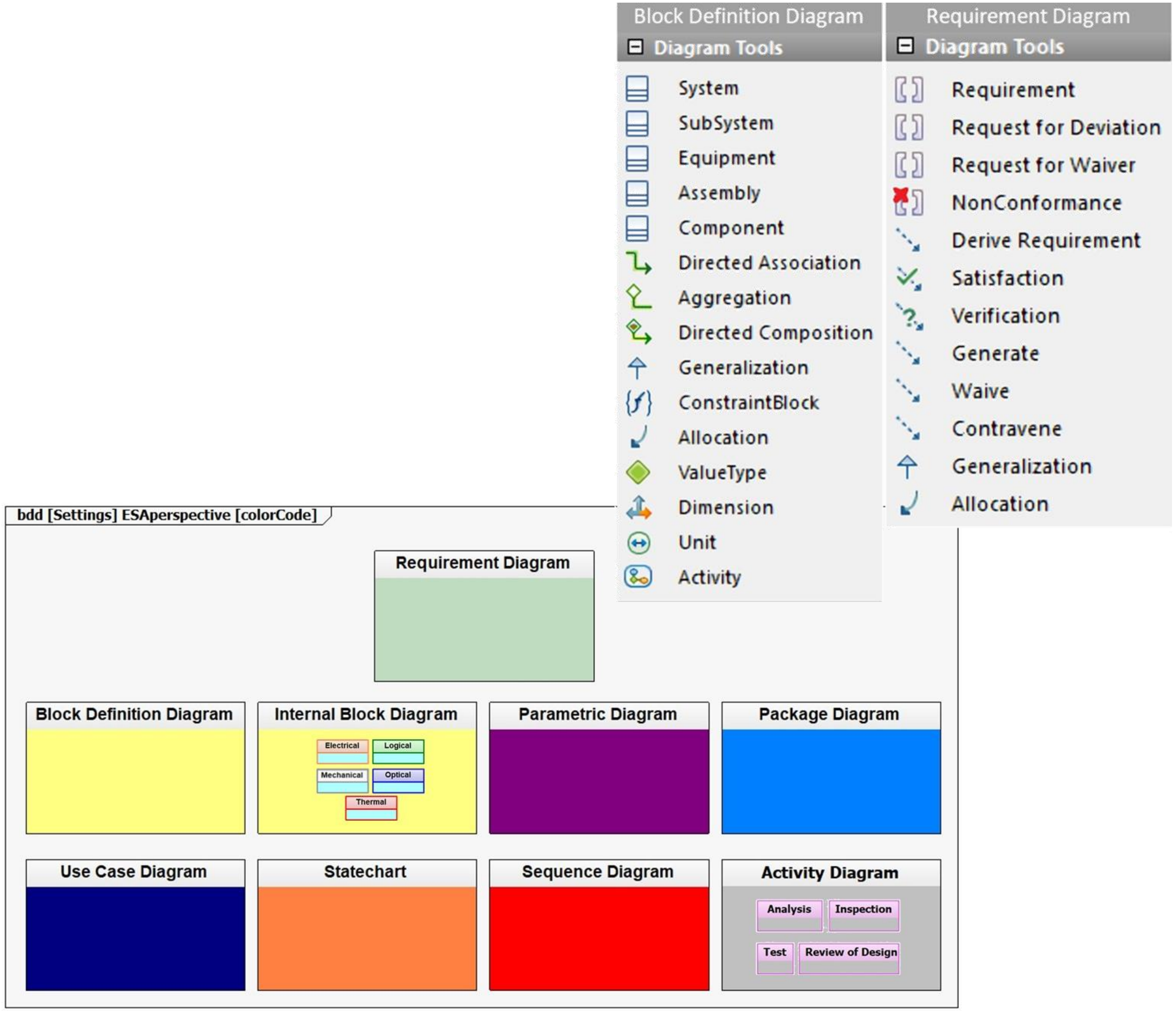
3. ESA Profile
Implementation

Diagram Tools and **menus** have been customized to display elements to be used.

An **ESA Perspective** has been created with new stereotypes for each diagram to adopt the required color code.

Auto explicative Diagrams have been included to display the new elements and how to model with them.

A complete **Value Types library** collecting basic and composite International System units has been added within the profile.



4. Model Overview

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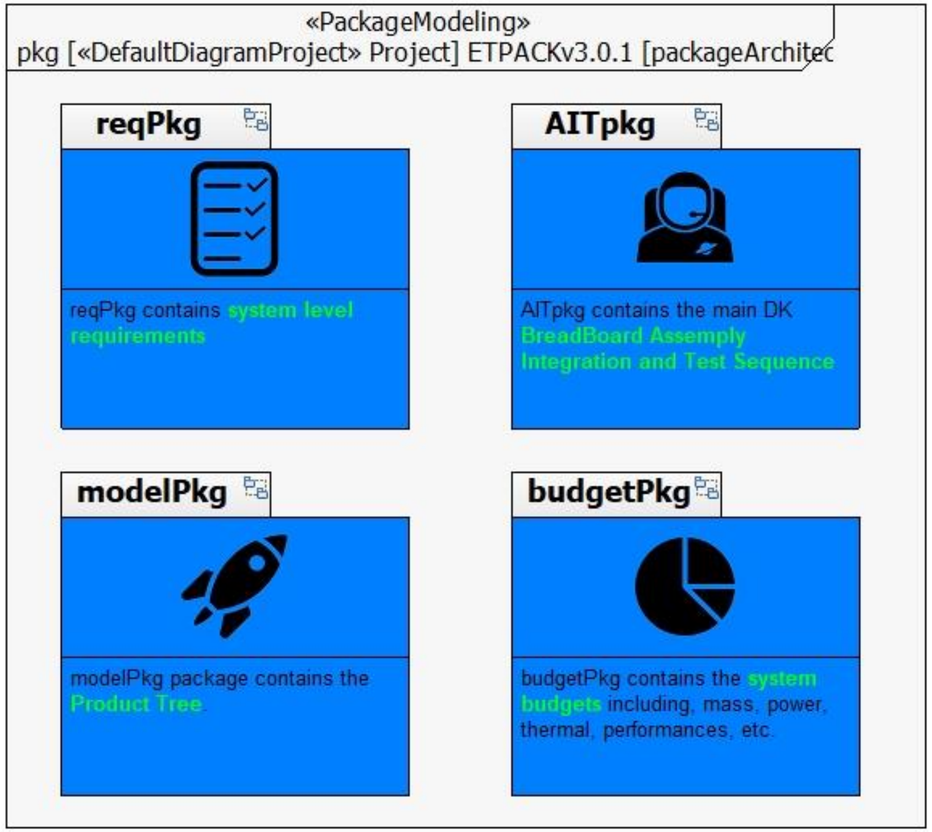
Main Packages

The E.T.PACK team is currently designing the **Deorbit Kit Demonstrator mission.**

The DKD model is divided into **4 main packages**:

- Requirement.
- Budget.
- Model (structural and behavioral diagrams).
- Assembly Integration and Test plans.

This structure is represented in a **Package Diagram** that appears automatically, along with the welcome screen, when opening the model and from which the user can access the different packages using quick navigation.



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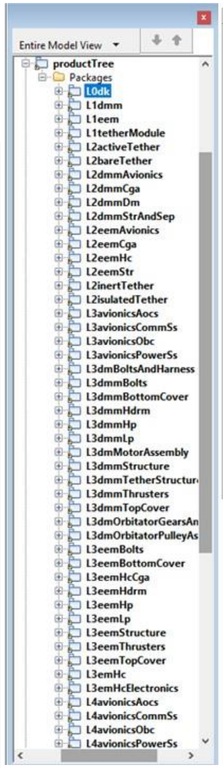
4. Model Overview

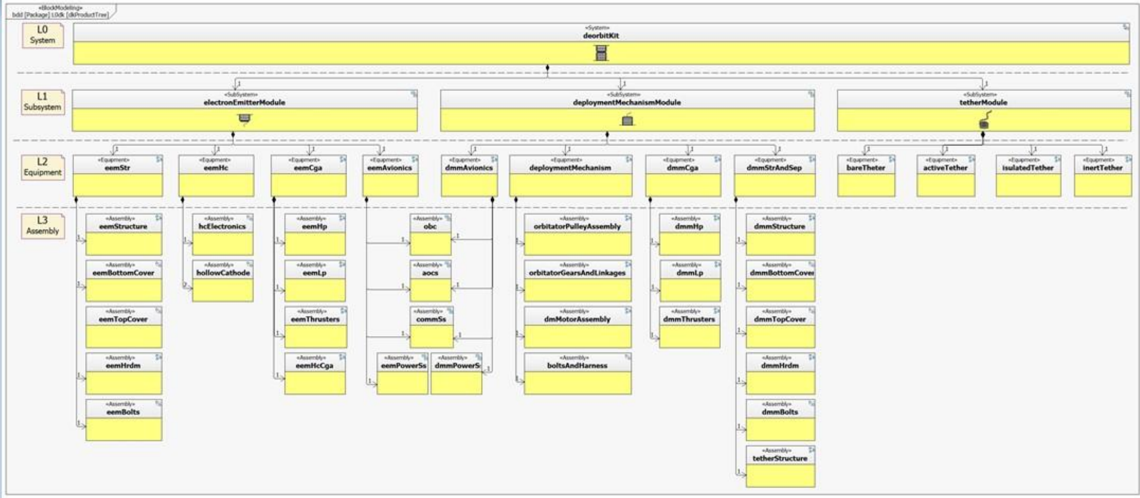
Browser Organization

Modelling a SysML project with thousands of graphical elements is a complex task with **conflicting needs** of **maintaining hierarchy** while **allowing concurrent working.**

The 5 types of **structural elements were associated with a level number** from L0 (System) to L4 (Component).

The Browser is organized using *dedicated* packages for each element from L0 to L3 and *multi-element* packages including all the L4 Components with a common L3 parent.





This structure enables to:

- Maintain an **organized browser** with little navigability through packages to access the elements.
- Lock, make changes and unlock the desired packages in **concurrent work.**
- **Reuse** elements to display in different diagrams.
- **Prevent duplicate** elements.

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4. Model Overview

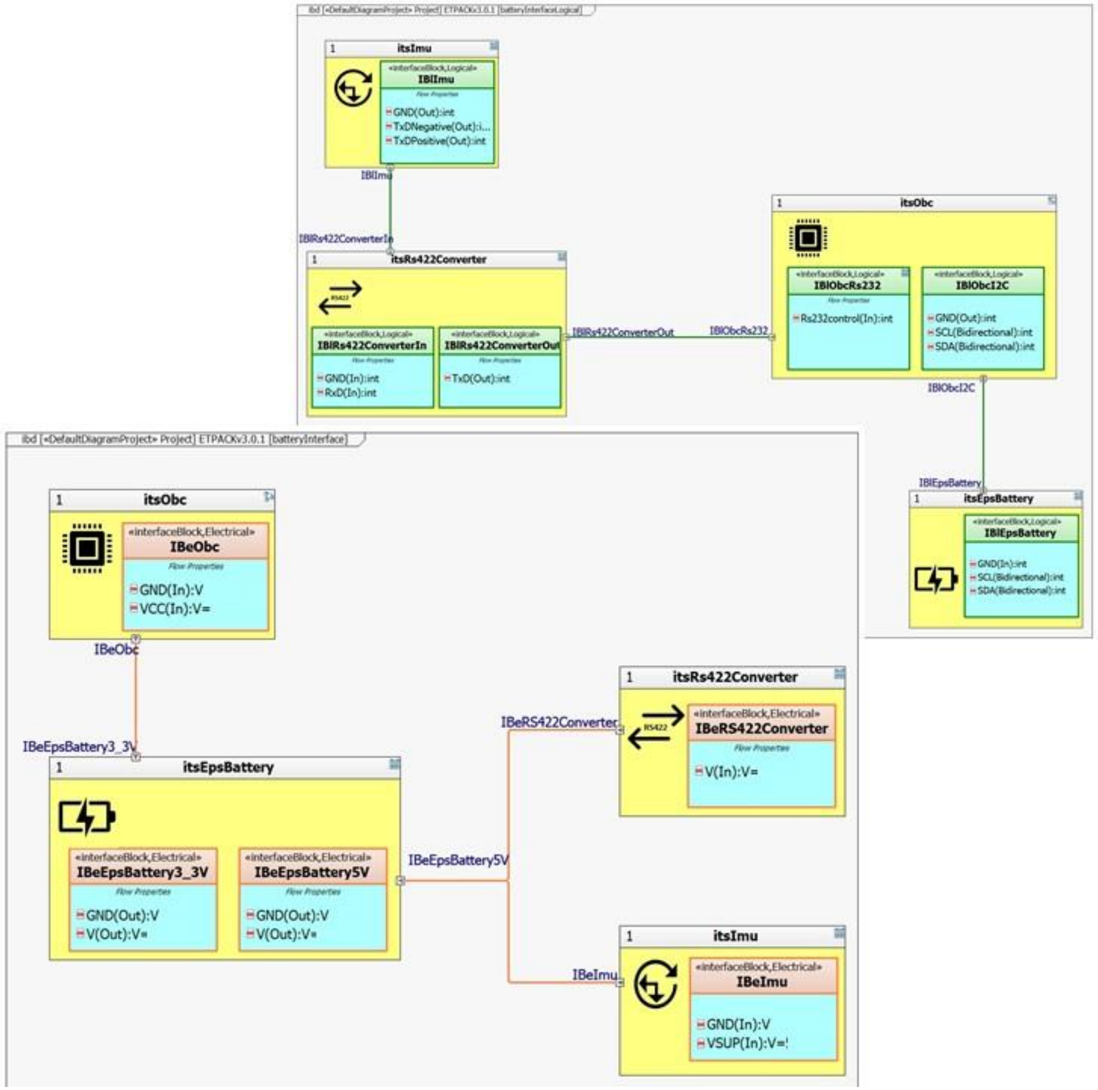
Naming convention

One of the most critical decisions in a SysML model is to **establish a clear, functional and maintainable naming convention.**

Since the graphical objects are of reduced size, names shall be as **short** and as **precise** as possible.

The **element level** (L0, L1, L2, L3 and L4) is **part of the name of the package** to clearly organize the elements in the browser according to the system decomposition.

Elements related to elements from the product tree include the name of the latter.



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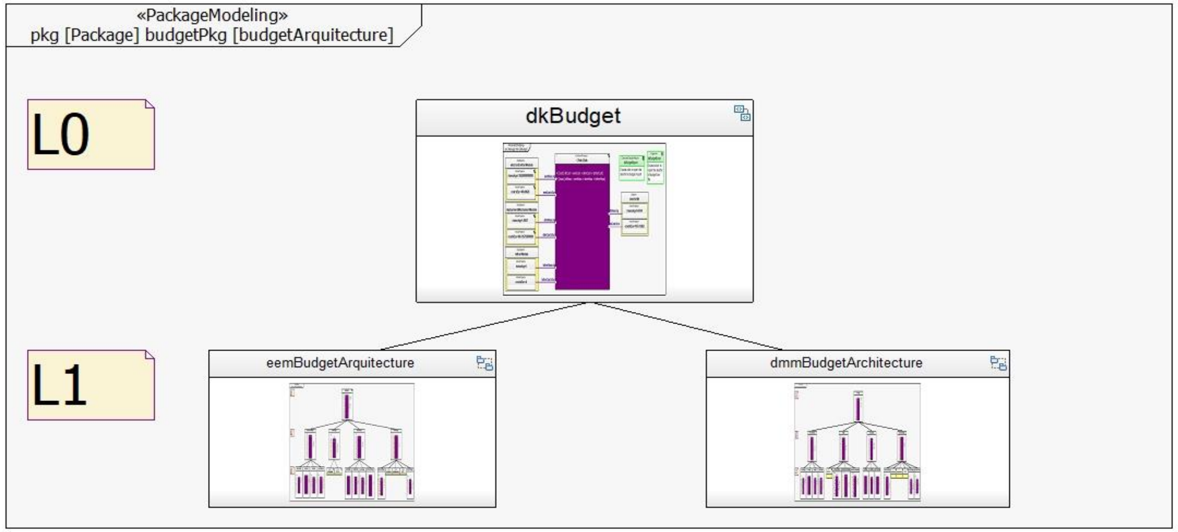
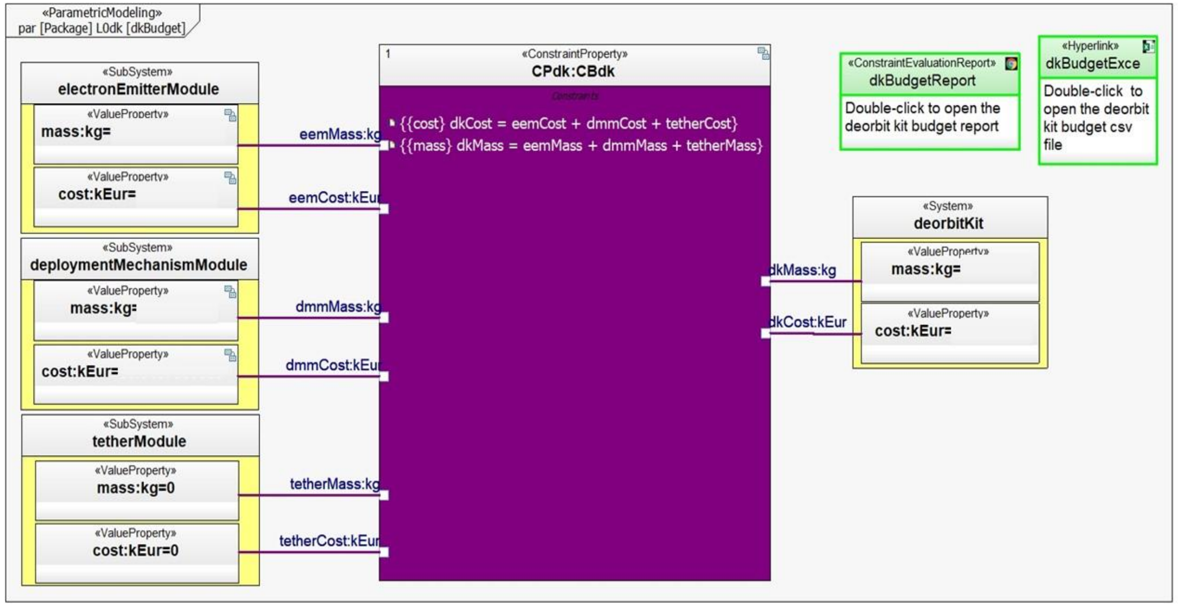
4. Model Overview
Fully Navigable Architecture

One of the main advantages of using MBSE is that **each diagram displays exclusively the relevant information** and not all the information available in the shown elements.

This guarantees to describe the system with focused and consistent diagrams. A potential drawback is the **diagram proliferation that requires a proper management.**

The organization of the **diagrams in a navigable architecture** is of paramount importance for maintaining the model clear and easily accessible.





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5. Team Formation

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Mastering SysML is not easy, the learning curve is very steep, software is expensive and little training material is available online.

SENER prepared a **16-hour intense training program** for kickstarting the consortium in the use of the DKD SysML Rhapsody model.

A total of **13 engineers from SENER, UC3M, TUD and UniPD** received the SysML training and started modeling their subsystems.

The feedback received so far has been very positive, but it is still too early to draw final conclusions since the real collaborative work on the model has not started.

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6. Roadmap & Future Plans

6. Roadmap & Future Plans

The DKD mission is the first step for the **development of a commercial system product** that will have many differences with the initial design. The potentiality of the tether technology is huge, and it allows deorbiting, re-orbiting and station keeping.

A **business development study** is currently **ongoing** to determine the most promising application.

We firmly believe that SysML will allow to **maximize** the design **reuse** and to **develop independent "branches"** for each deorbiting product foreseen.

7. Conclusions

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The **Deorbit Kit Demonstrator mission** is currently **in development** under the umbrella of the E.T.PACK project.

SysML language and IBM Rhapsody tool have been selected for describing the design to maintain an updated system description, avoiding static documents.

To overcome the SysML ambiguity, the **ESA Profile has been adopted** and tailored for the DKD mission design.

The model follows a **package structure** that allows to navigate through the Browser easily.

The key for efficient model organization is establishing a **clear naming convention** and straightforward **modeling rules**.

Team formation results to be **fundamental** to lower the steep SysML learning curve and start a real concurrent process.

SysML is an investment for the project, but it is very **limited** with respect to the future benefit it will bring.

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References


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