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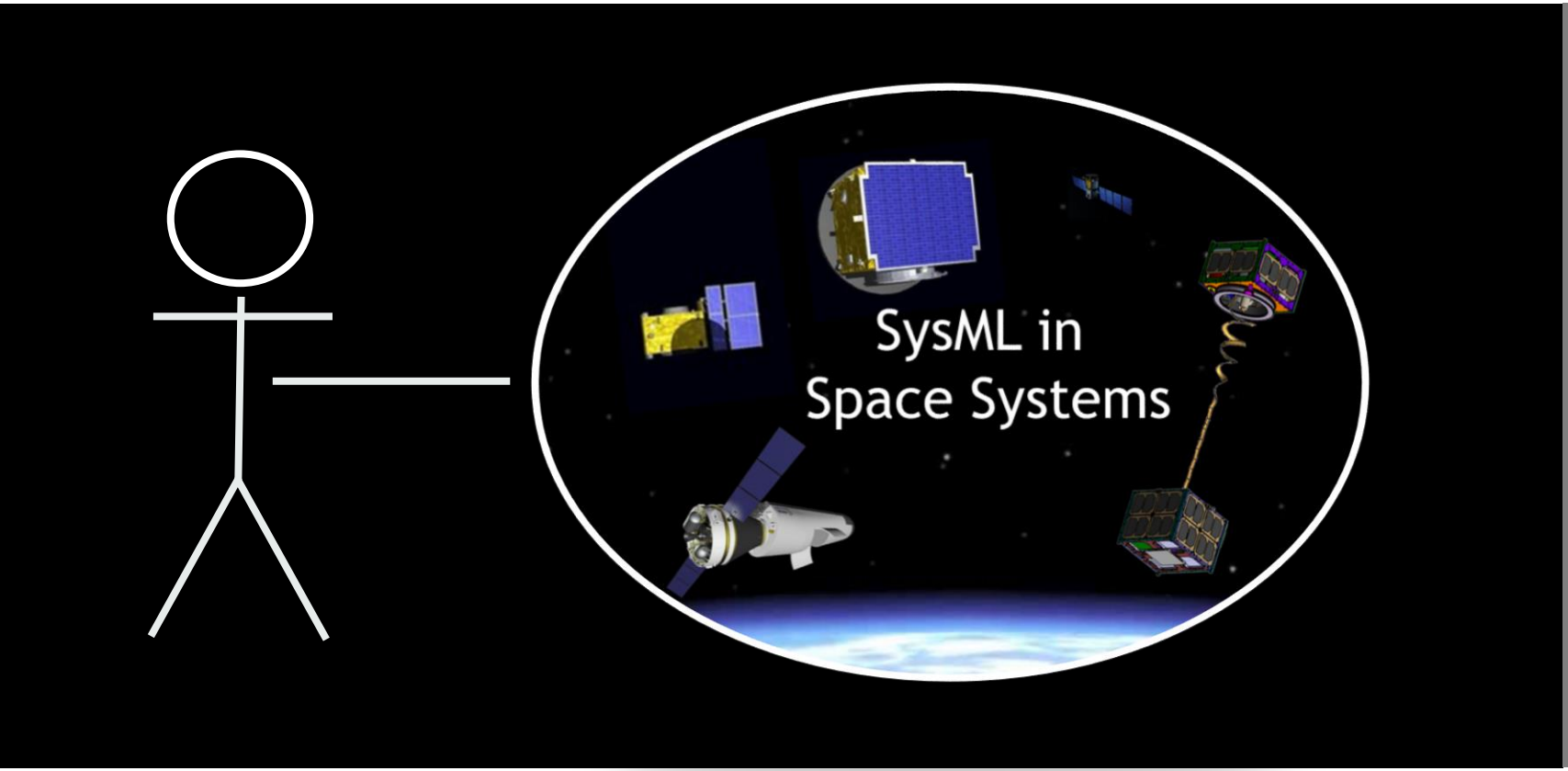
Aeroespacial

28 September 2021



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Lessons learned from the use of SysML in Space Systems at SENER Aeroespacial

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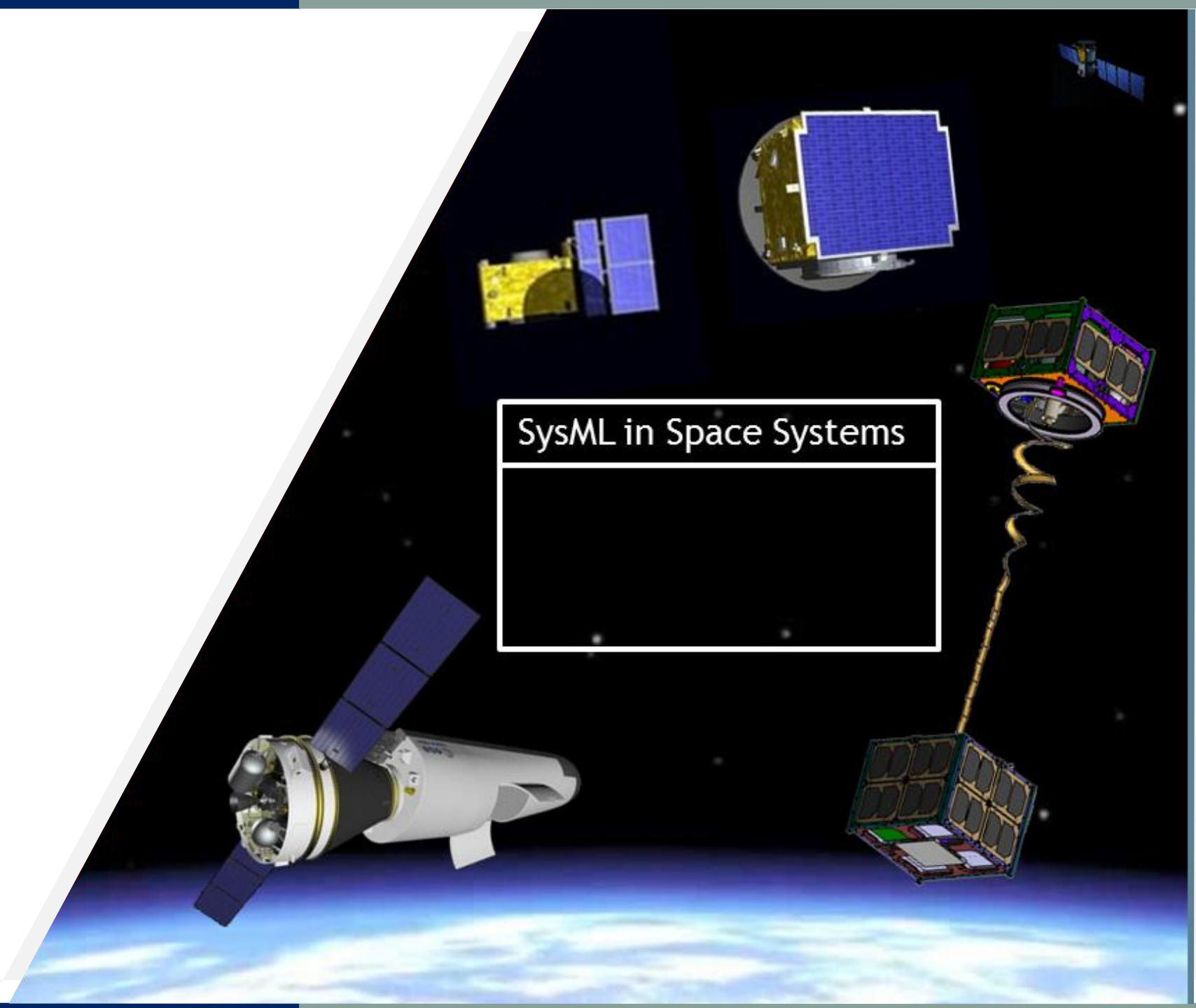

1. Introduction

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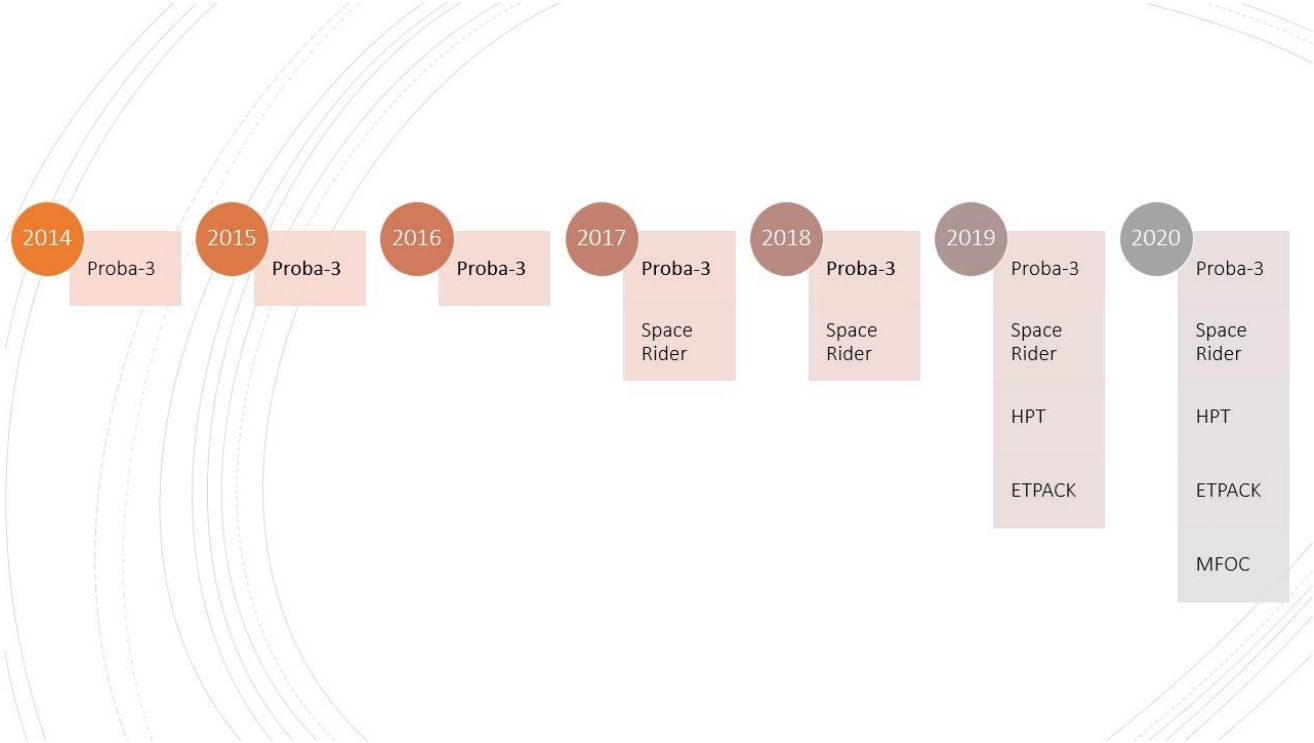
SENER started using SysML for Space Systems in 2014.

Since then, the number of SENER projects adopting this technique has grown including:

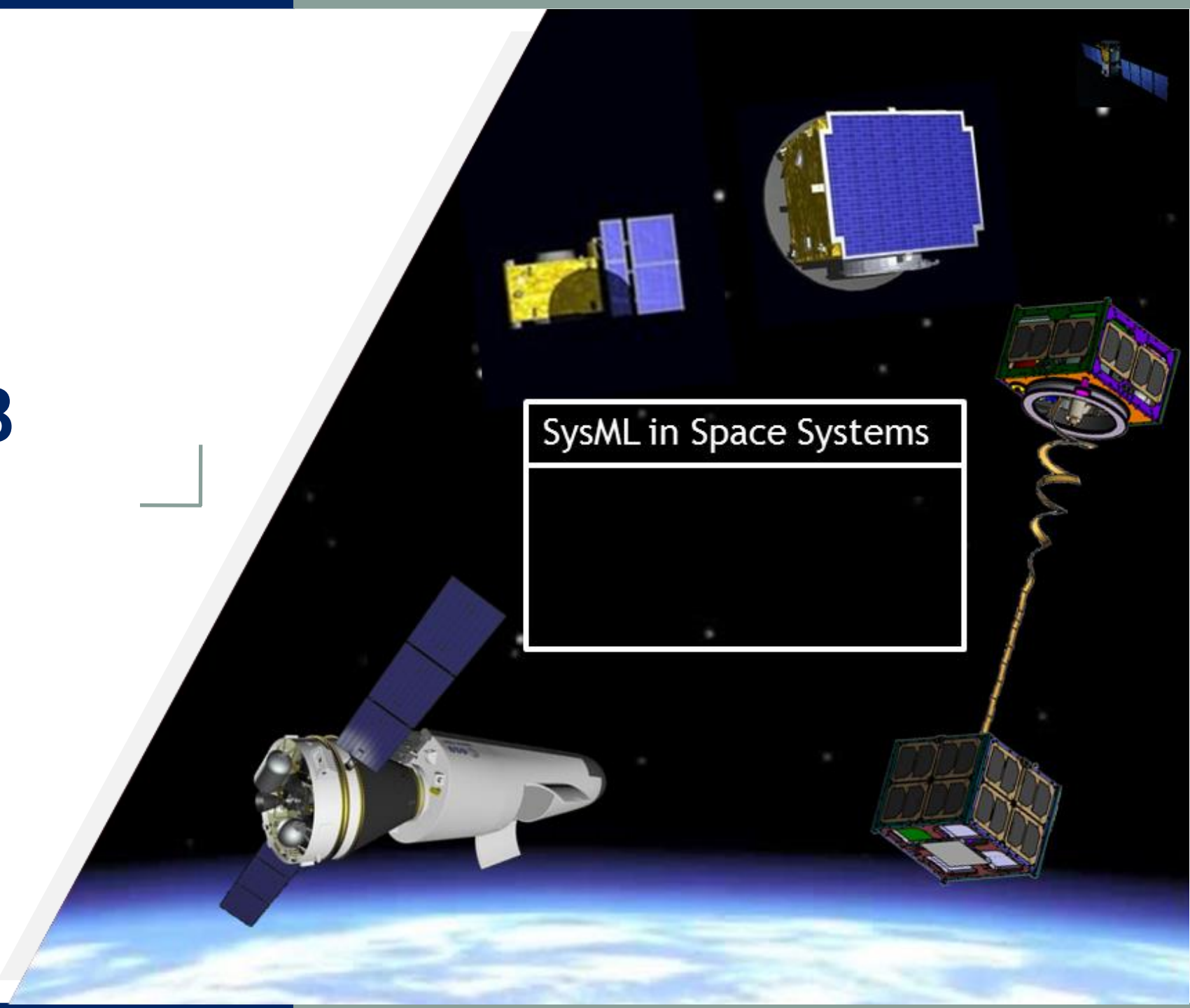
- Full flight systems
- Subsystems
- Equipment

This presentation deals with the evolution of the SysML use in SENER describing:

- The reasons to implement SysML
- The benefit achieved and
- The main lessons learned from its adoption.



2. Proba-3



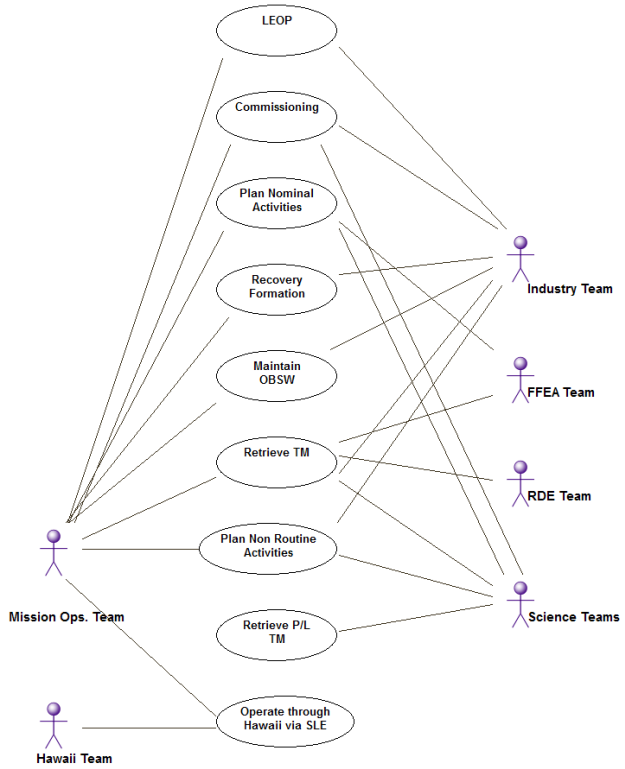
2. Proba-3
Getting Common Understanding

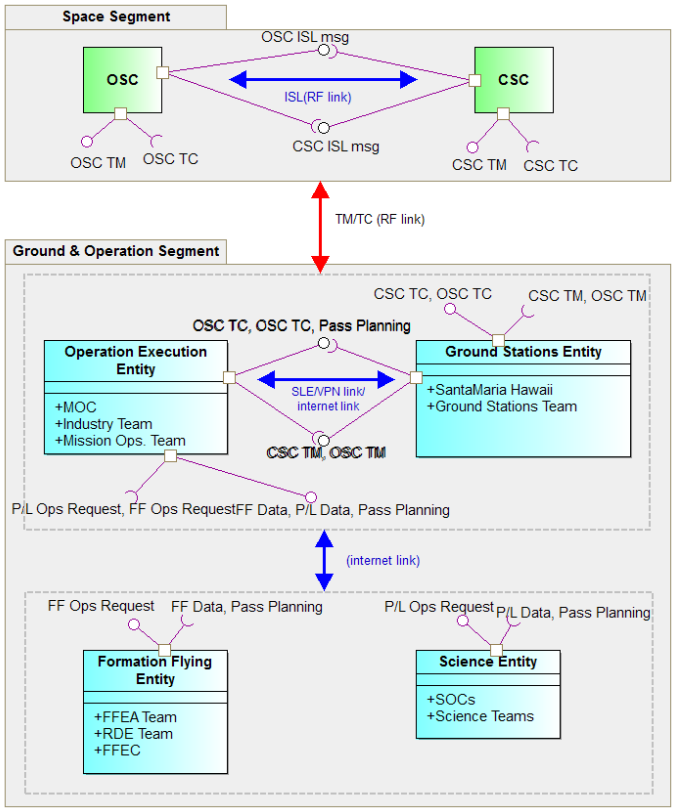
In 2014, at the beginning of phase C, SENER as prime contractor was in charge to define the Proba-3 ground segment and operations approach.

Challenge: adapt the Redu ground station and the Proba1&2 operations environment to Proba-3 formation flying operations.

SysML diagrams used to:

- Prepare Ground Segment use cases
- Trade Flight autonomy vs Ground autonomy vs Manual Operation
- **Achieve final consensus in due time.**





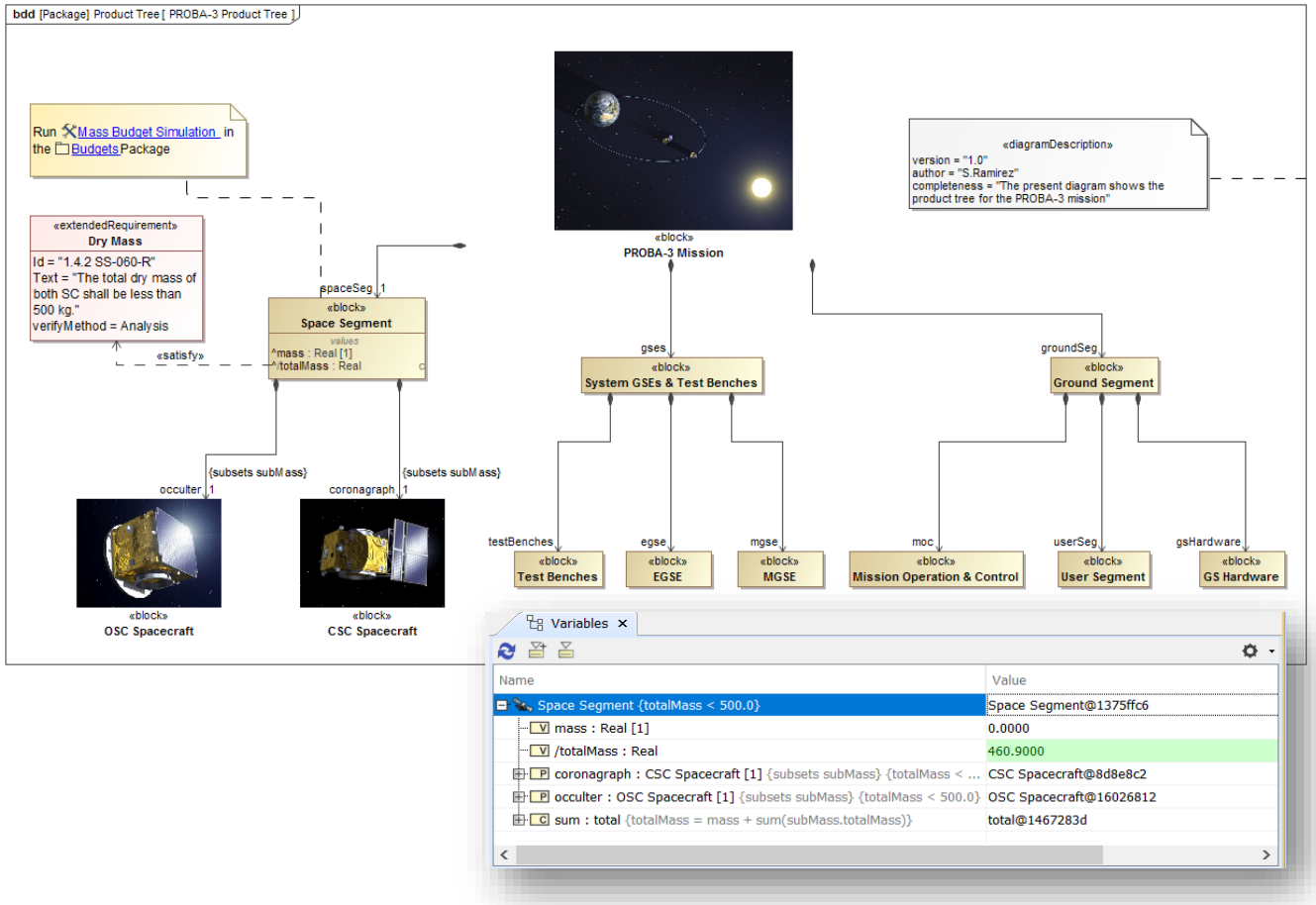
2. Proba-3
Systematic Requirements Definition

In 2015 SENER was responsable of the specification of critical PROBA-3 mission subsystems

Challenge: define correct subsystems requirements.

SysML was used:

- For **defining unit requirements** from the use cases.
- For **modelling the complex mode architecture** including spacecraft modes, Formation Flying modes and the GNC modes at spacecraft level.
- For the **independent design verification of the FDIR system**,
- For **budgets generation.**



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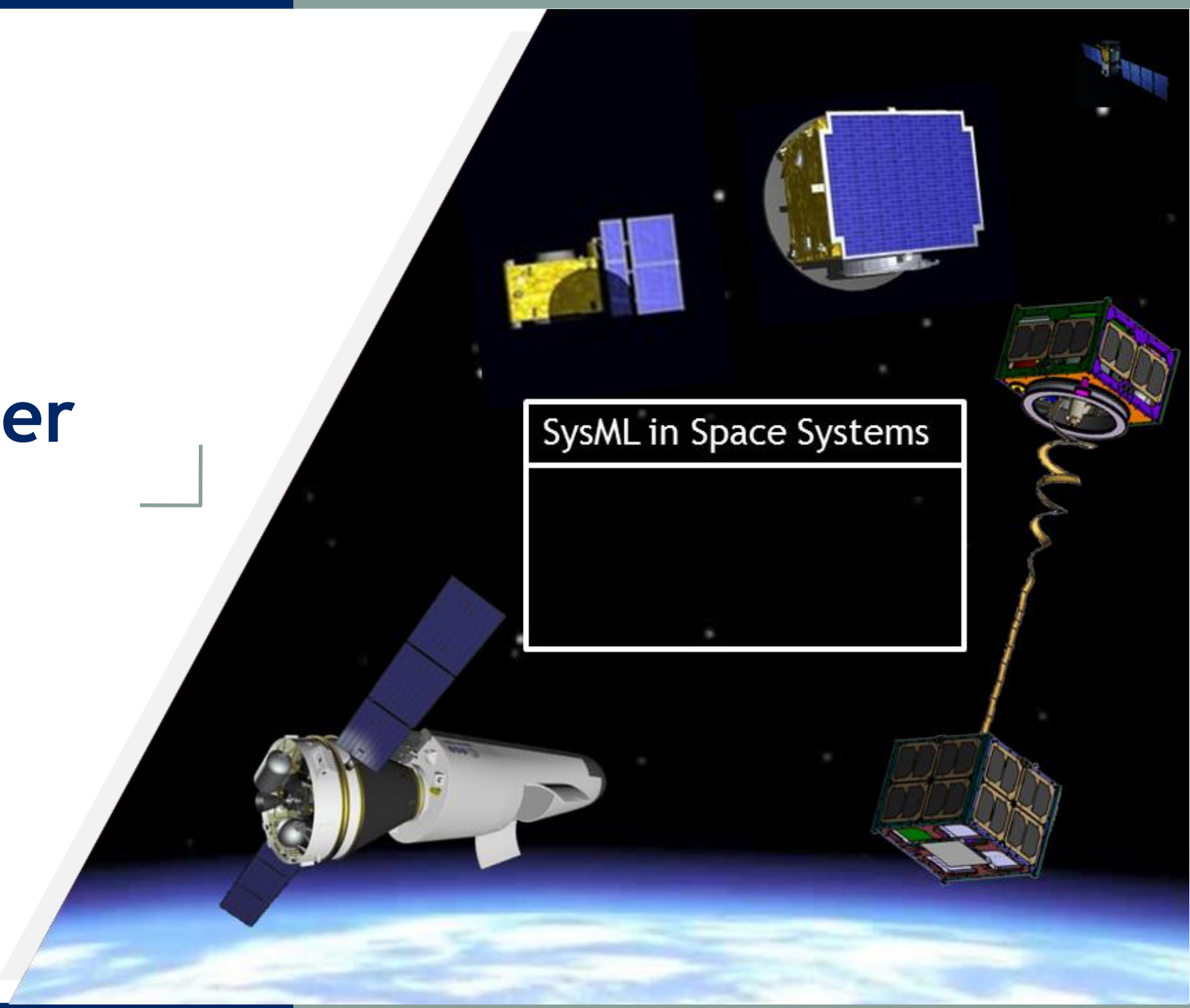
3. Space Rider



3. Space Rider

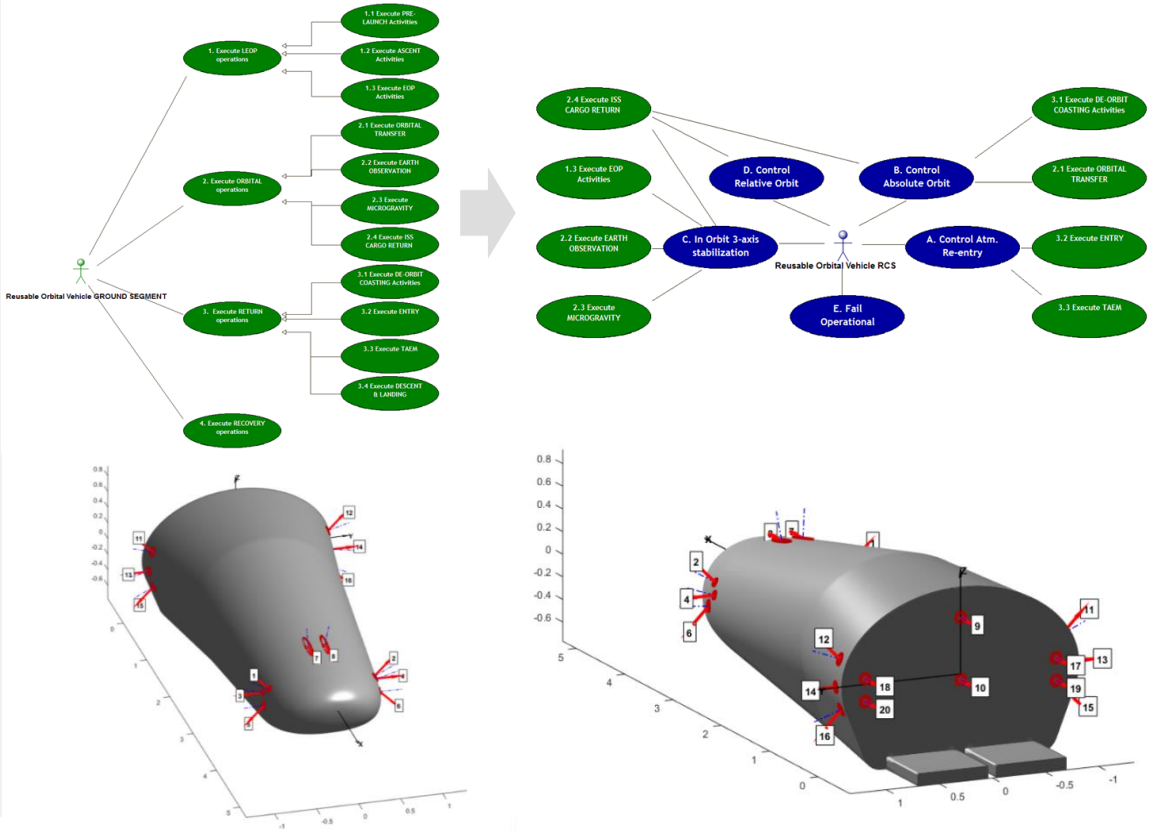
Consistent Requirement Derivation to GNC Subsystem

In 2017, during phase A/B1, Space Rider was under Thales Alenia Space and CIRA co-primeship and SENER was responsible for the GNC including the requirements definition.

Challenge: design GNC from System Requirements.

Adopting SysML methodology, SENER:

- Defined GNC use cases
- Identified critical requirements and autonomy level.
- Specified GNC functions ad-hoc to satisfy each requirement.



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3. Space Rider

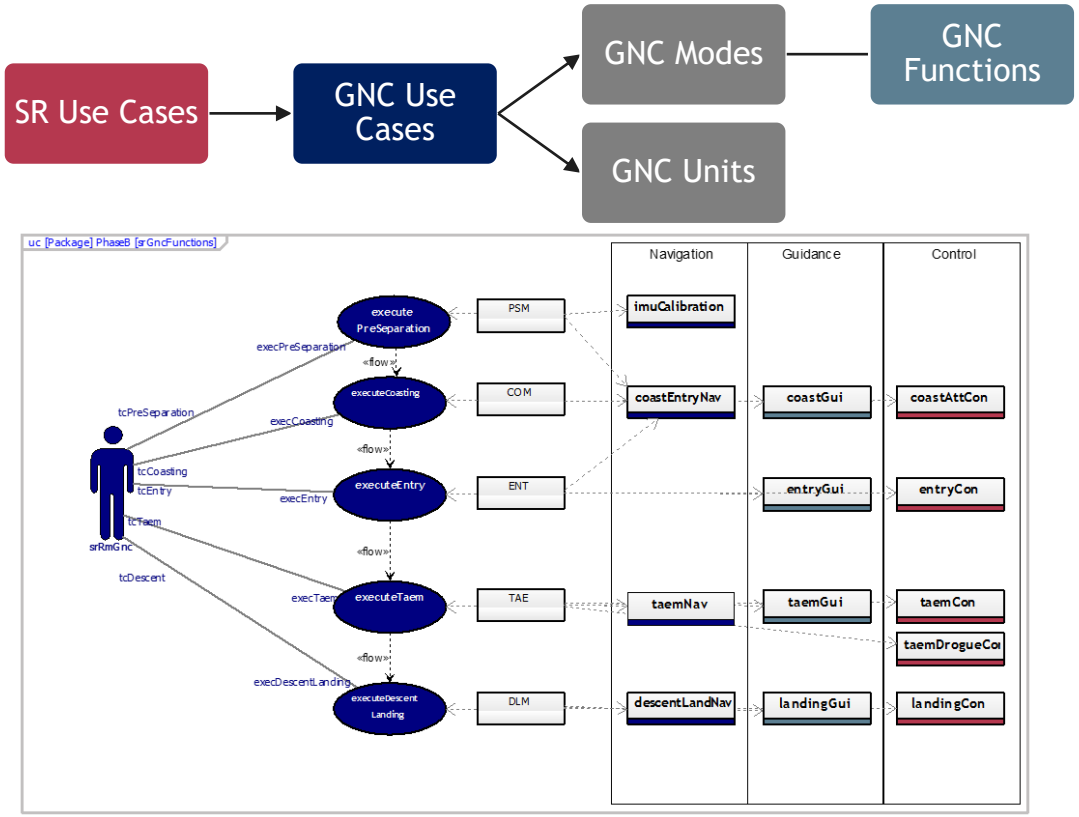
Design Change Handling & Precise I/F Definition

In 2018 Space Rider mission and system was substantially updated. The modified VEGA AVUM was selected as external orbital module and SENER, that designed an integrated GNC system suitable for the orbit and re-entry phase should adapt the GNC exclusively for the Re-Entry Module.

Challenge: handle major system change.

Thanks to the SysML digital design,

- The change was absorbed with limited impact.
- Re-entry GNC functions were adapted according to new use cases.
- Clear GNC interfaces were put in place and maintained.



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4. Helicon Plasma Thruster

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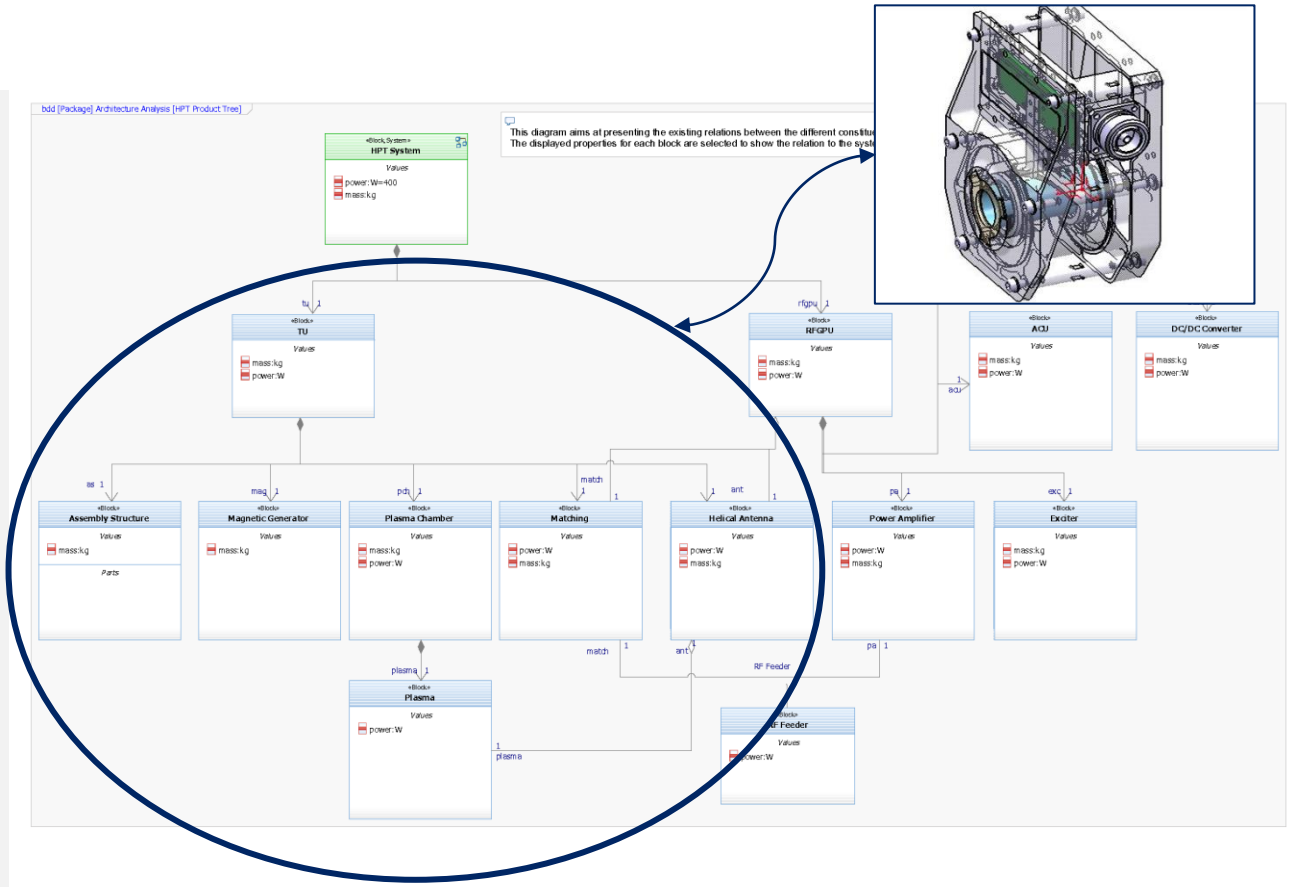
Review on Models

The Helicon Plasma Thruster (HPT) is a radio frequency-powered plasma propulsion technology that can perform well while eliminating many issues that have affected Electric Propulsion Systems (EPSs) to date. SENER started the development of the HPT in 2013 in collaboration with the University Carlos III of Madrid, based on internal funding and ESA's GSTP support programmes.

Challenge: Speed up the design loop review.

In 2019 SENER started to implement and maintain the **complete system design of the HPT in SysML.** With that, all the **project reviews are performed directly on model's views** reducing to the barely minimum the technical documentation.



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5. Madrid Flight On Chip

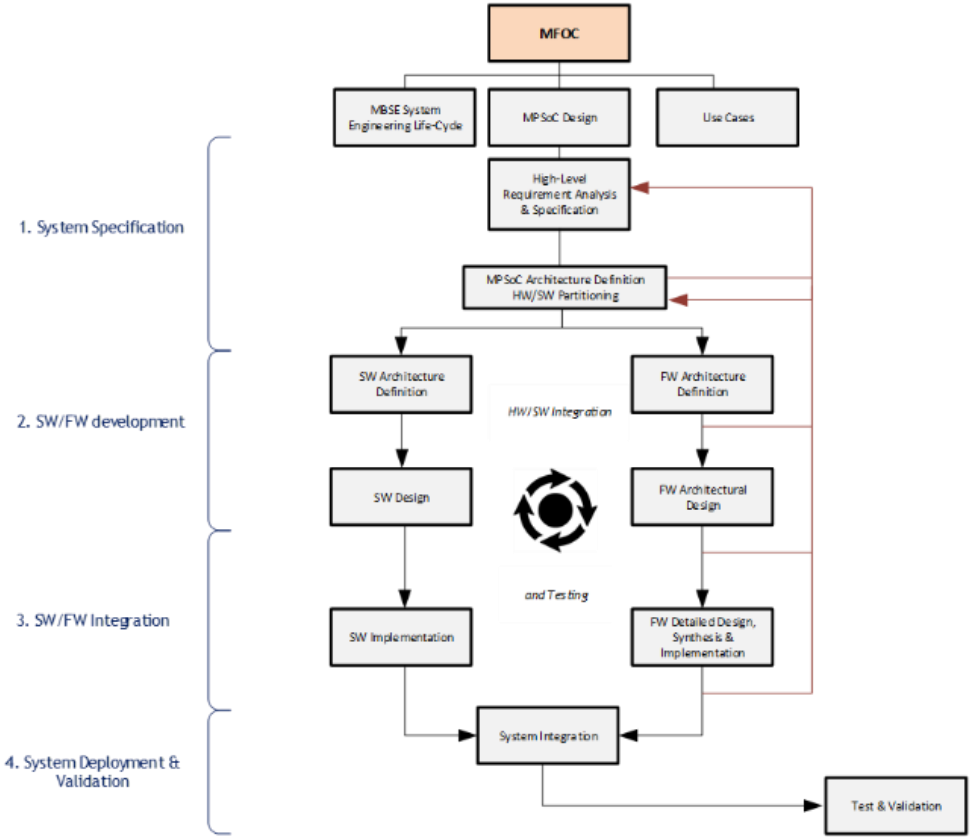
5. MFOC
SysML Internal Standardization

The Madrid Flight on Chip (MFOC) is a project funded by Comunidad de Madrid to develop an execution platform based on **MultiProcessor System on Chip** (MPSoC) **for future new space applications and satellites**.

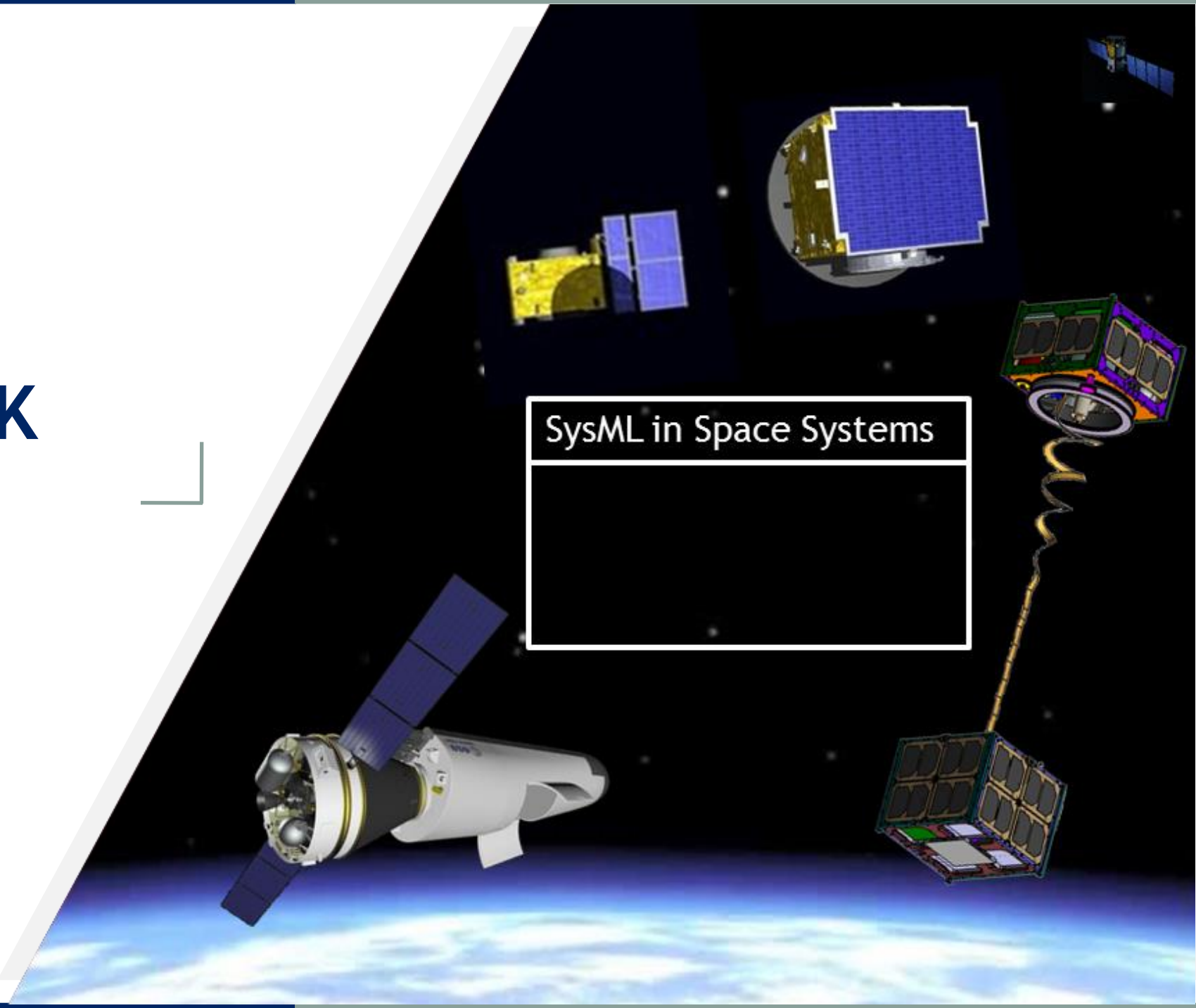
MFOC started in 2018 and includes work packages dedicated to advanced use of MBSE and in particular to SysML, integrated in a complete engineering design environment.

Challenge: standardize SysML use in SENER.

Within this activity, SENER is working with The Reuse Company since 2020 to maximize the exploitation of the SysML tool and its connectivity to other system design tools.



6. E.T.PACK



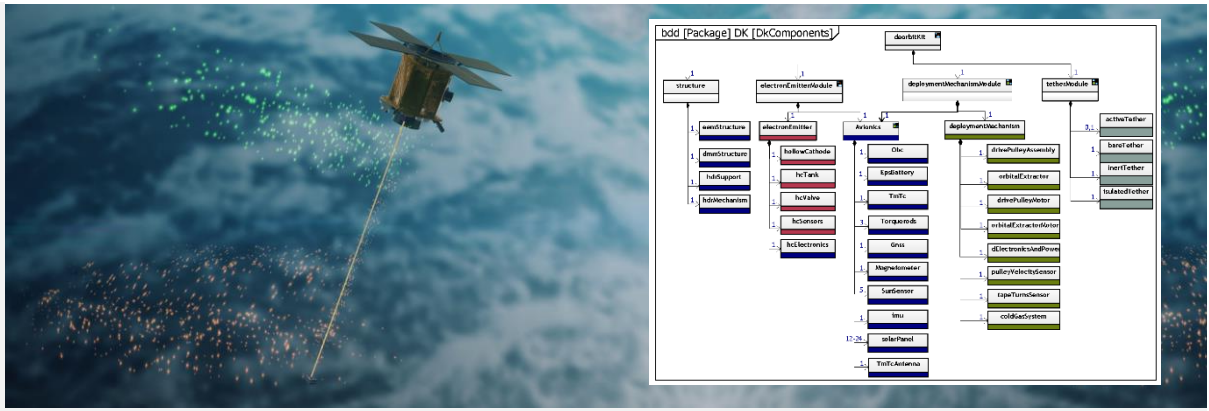
6. E.T. PACK
Documentless Design

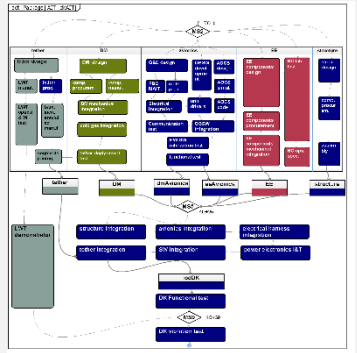
E.T.PACK is an EU funded project aimed to design a **deorbit kit device based on electrodynamic tether** and develop a prototype up to TRL4 by 2022.

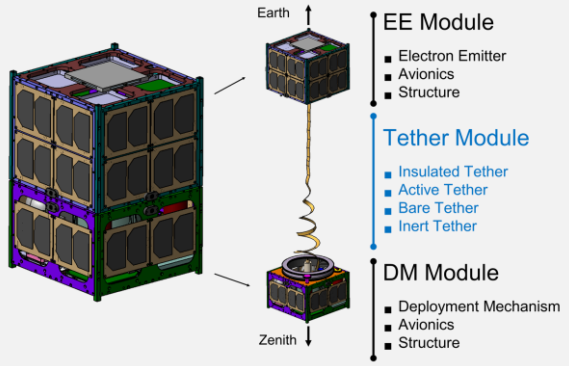
Challenge: reduce to the minimum the cost of the technology development that will hopefully end in a demonstration flight in 2025.

ETPACK is following the successful HPT SysML implementation scheme taking full advantages of the lessons learned and building on it.

Given the low TRL, several design iterations are expected and SysML has been selected for the design description.







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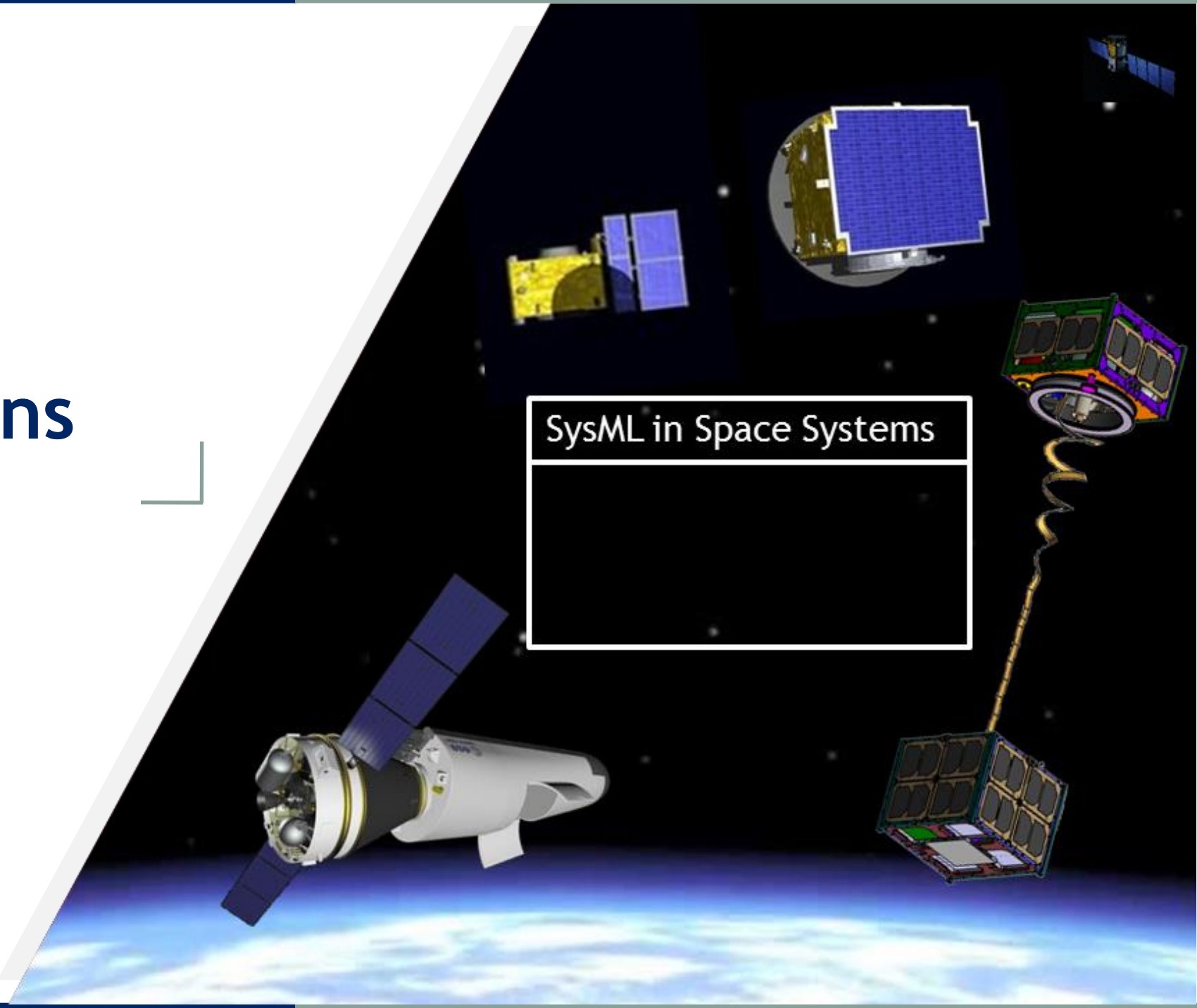
7. Conclusions



7. Conclusions

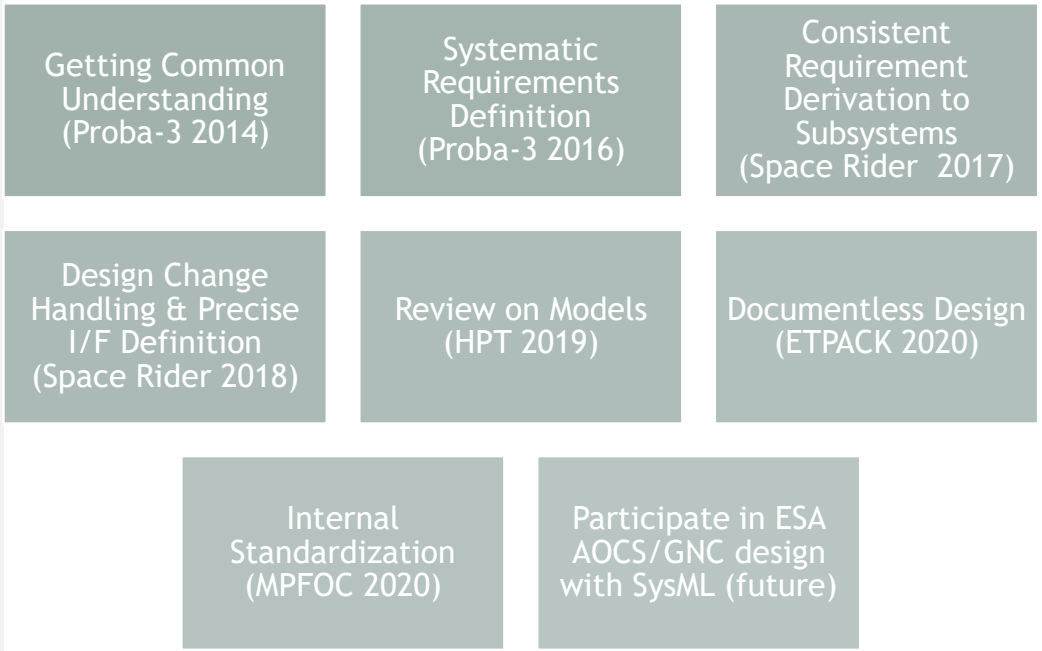
Since 2014 SysML is used for internal developments, proposals, ESA and EC projects. SENER is also teaching SysML for Space at the University Carlos III of Madrid.

SysML allows mastering the complexity with a reduced number of graphical elements and associated documentation.

The standardized SENER working procedure guides the engineer in the early task of requirement definition up to the level of definition of the component detailed design.

The increase in the engineer's productivity results has demonstrated to lead to higher project efficiency with consequent saving of money.

The key for methodology acceptance is that different projects have adopted SysML at different levels according to their needs and expectations.



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