

## Lessons learned on the use of MBSE in the preliminary design of space systems at CT Paris

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Formerly part of Bertin Technologie, the Paris office of the CT Engineering Group has a strong expertise in innovative space system design and High-performance computing simulation.

During the last year, the group has started to implement the Arcadia method supported by the Capella tool in several projects. The choice of the Arcadia method was driven by its 'customer-friendly' first steps (Operational Analysis & System Needs Analysis), that allow to check the adequacy of the prototype system relatively to customer requirements and expectations. Another expected benefit was the completeness and the consistency of the created system. Eventually, the possibility to capitalize in the created system for later development phase, and especially for the interaction with potential supplier, was also a main driver for change.

We developed models for different projects including:

- Our patented space debris mitigation system INSIDeR (an inflatable net aiming to capture space debris)
- An innovative space braking system for just-in time collision avoidance
- Launcher ground segments

Although the main concepts were already conceptualized, the use of the Arcadia methodology in support of the preliminary studies has revealed relevant, particularly to prepare the way forward for those low-TRL systems.

The modeling of the nominal situations and components has enabled a refinement of the preliminary requirements thorough the study.

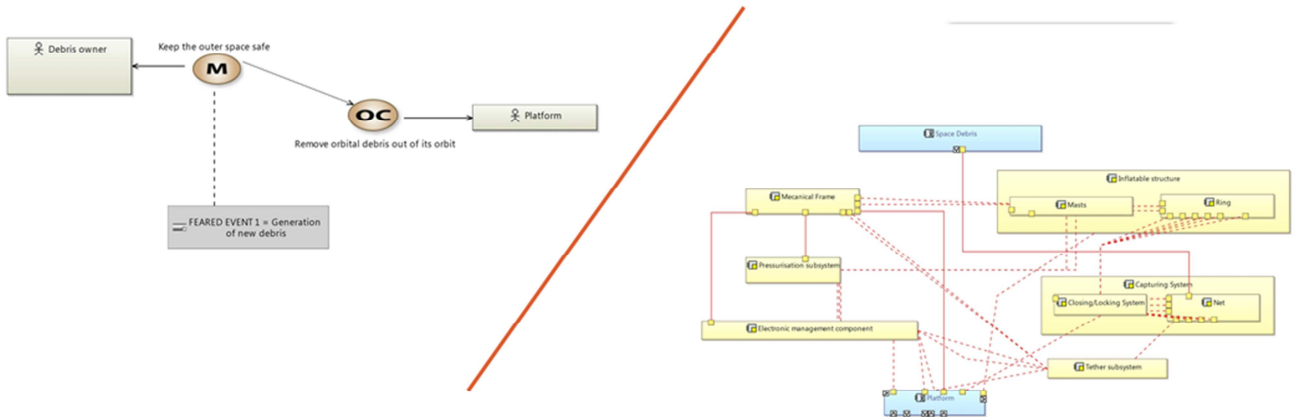
The modeling of non-nominal situations and feared events has enabled to consider new problematics. For instance, in INSIDeR, a system aiming to close the net and capture the debris has been designed. The analysis of a feared event 'creation of new debris' has conducted to further studies on the system design to ensure that a single link break in the system will not entail the separation of any subsystem of the inflatable structure.

The paper will also present how the traditional value analysis methodology and the Arcadia method are complementary. One may cite among others:

- The management of the feedback loops between customer expectations and real system behavior is facilitated by the centralization of all the system characteristics.
- The management of the heterogeneity in subsystem conception, both in the liberty Arcadia method gives to build the models and in the maturity of the different subsystem.
- Automatic and formal verification of the completeness of the work, with the automatic validation and transitions between Capella layers.

Once created, the model has been (or will be) used for several purposes:

- Description of the dynamic behavior of Insider for communication purpose at various levels.
- Management of interfaces with the satellite in which the system will be embedded.
- Streamlined description of sub-systems to be realized, with their associated requirements, functions, interface and behavior, allowing the communication with potential suppliers and used for the development roadmap of the system.



Insider and Arcadia / Capella : from Customer mission to first system design

The Arcadia/Capella approach is a complementary method to the classical preliminary design methodologies. The use of MBSE at the early stage of a project allows to prepare the next development phases with a common system architecture that can be share by all future stakeholders of the project.