Towards Enhanced collaborative Process and Tools for Aircraft Systems Assessments valid during all Design Phases

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1. Introduction

Designing complex systems, such as aircraft, is a challenging task due to the growing number of components and stakeholders involved. These systems are comprised of numerous interconnected subsystems developed by various design partners and architects. The design process involves creating architectures and subsystems that satisfy requirements defined at higher levels, while considering multiple constraints to achieve a safe and high-performing aircraft that meets user expectations and certification standards.

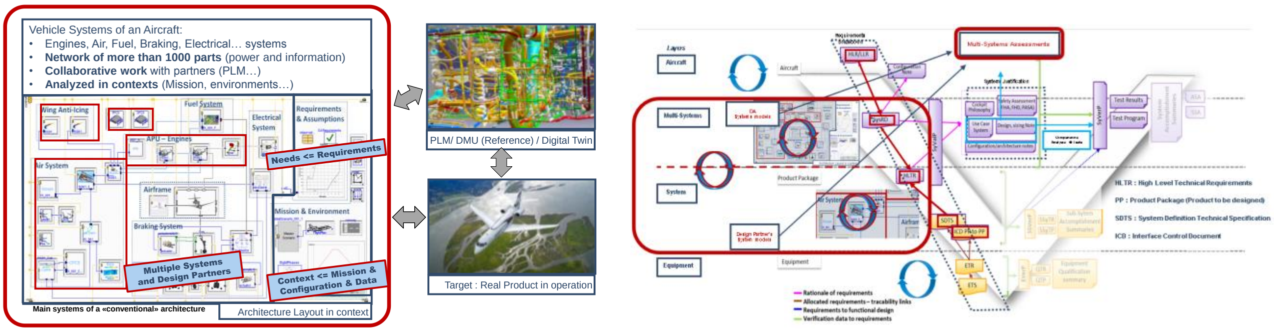

Figure 1: Architecture layout of aircraft systems and common decomposition layers of an aircraft and V&V

To address these challenges, a range of systems engineering methods and processes have been explored and documented by different researchers. These approaches generally focus on the design and management of requirements and architectures, as well as on overseeing verification and validation (V&V) primarily through traceability. System designers typically receive requirement documents through a top-down approach, cascading from the aircraft level down to individual systems and components. They must then verify and validate their designs using a bottom-up approach to demonstrate compliance with these requirements.

The purpose of this paper is to present the findings from various projects aimed at improving collaborative design practices to achieve a more streamlined and agile process.

2. Methods

Initial research was focused on enhancing architecture assessment methods for getting more efficient cyber-physical simulations of complex architectures. It was done mainly by improving open standards such as the Modelica language and FMI, as well as associated tools, through several projects (e.g., ITEA EUROSYSLIB [4], ITEA2 MODRIO [9][10]). With these standards reaching sufficient maturity, subsequent research shifted towards collaborative design, supported by dedicated projects like Systemic CSDL [13] (Complex System Design Lab), FP7 TOICA [6][7][8][12] (Thermal Overall Integrated Concept of Aircraft), Cleansky2 [11] MISSION (Modelling and Simulation Tools for Systems Integration on Aircraft), and the ongoing DGAC EXCELAB (Extended Collaborative Engineering Laboratory).

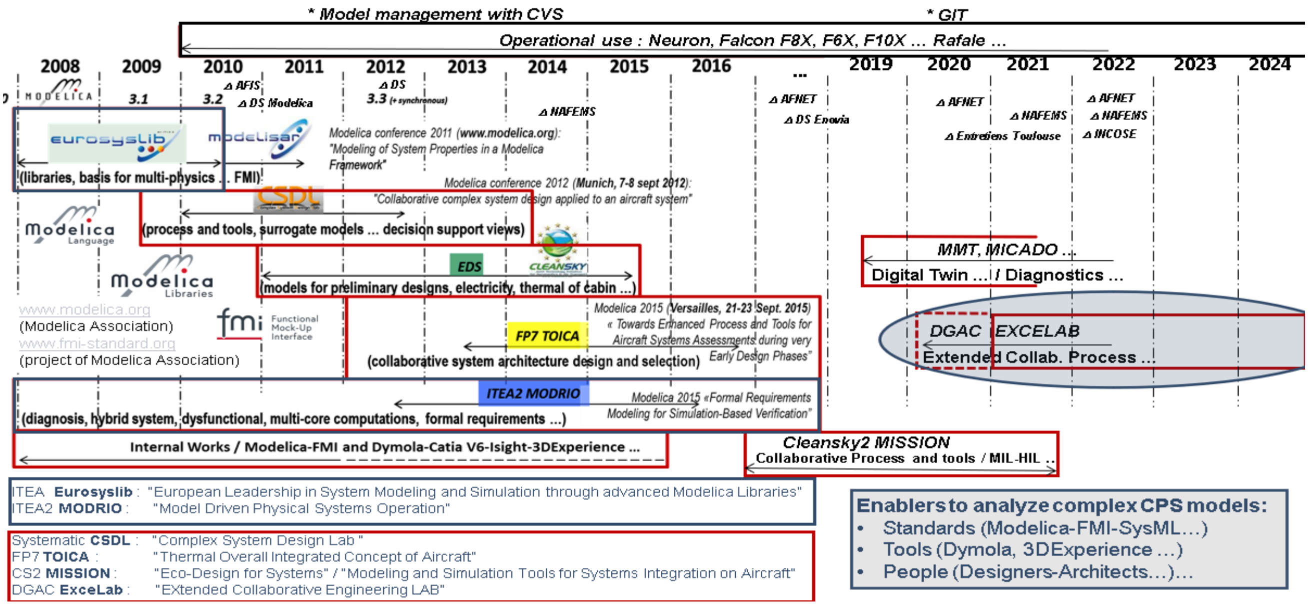

Figure 2 : Project roadmap for better cyber-physical systems assessments and collaborative design

The research primarily aims to develop a more effective collaborative process for multi-system assessments, bridging the gap between traditional systems engineering and behaviour assessment. Throughout these projects, the research has evolved significantly, shifting from a platform leveraging Modelica language capabilities (CSDL) to processes and tools based on both SysML and Modelica, reflecting their broader adoption globally and at Dassault Aviation. The focus then moved from Modelica-centric processes and tools (TOICA and MISSION) to a more SysML-oriented approach (MISSION and ExceLab), enabling a stronger link between assessment needs, requirements, and system architectures.

Use cases have been developed through collaborative design efforts for air systems with Liebherr Aerospace (TOICA, ExceLab) and flight control systems with Collins Aerospace (MISSION), utilizing a Model-in-the-Loop (MIL) approach during the TOICA, MISSION, and ExceLab projects. This was further extended to integration with real products (HIL: Hardware-in-the-Loop) during the MISSION project.

The current processes and tools aim to address complexity, accommodate real-world use cases, and operate under genuine industrial conditions, including the internal protection of data and models with proper configuration management. They are built on open standards (SysML, Modelica, FMI, SSP, Git, etc.) and are integrated as seamlessly as possible into real industrial platforms. The ongoing prototypes have matured and are regularly demonstrated in physical sessions, showcasing new capabilities every six months.

3. Results

The process is a tool-guided approach, leveraging open standards as much as possible while safeguarding the stakeholders' intellectual property. It aims to support designers in expressing their needs more efficiently, minimizing additional workload by automatically generating elements that enable collaborative multi-system assessments between aircraft and multi-system architects, as well as system designers, based on architectures and requirements. This methodology, rooted in the formal definition of shared studies, has been integrated into a broader process developed during ExceLab by major aircraft manufacturers (Airbus, Daher, and Dassault Aviation), covering all elements necessary for effective collaboration.

The prototype relies on several standards (UML/SysML, Modelica/FMI/SSP, Git, etc.) and is built on the tools currently used for collaborative design at Dassault Aviation, such as 3DExperience, Magic System/Teamwork Cloud, and Dymola from Dassault Systèmes. It primarily consists of a combination of tool customizations (via a DSL and a plugin in Magic System, as well as scripts) aimed at simplifying user interactions and automatically generating a framework for the formal definition of architectural analysis needs. These are represented in the form of studies that serve as the basis for developing the behaviour of these architectures in relation to requirements at various levels, following an iterative (agile) and flexible approach as much as possible.

4. Discussion

The purpose of this communication is to present the collaborative process currently defined, and the prototype developed by Dassault Aviation for aircraft collaborative design.

The existing process and tool prototypes aim to demonstrate their capability to seamlessly bridge the gap between traditional systems engineering (primarily focused on descriptive aspects) and assessment, ensuring their applicability across all design phases. These will be further refined with future advancements in standards (SysML v2.x, Modelica 4.x, FMI 3.x, SSP 1.x) and the enhanced capabilities of supporting tools.

5. References

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