



Model-Based Design of Onboard Software Applications for UAS-MALE

CIRA (Centro Italiano Ricerche Aerospaziali)

CIRA (Centro Italiano Ricerche Aerospaziali) was created in 1984 to manage PRORA, the Italian Aerospace Research Program, and uphold Italy's leadership in aeronautics and space. CIRA is in charge of designing and developing highly complex and innovative software applications for UAS-MALE (Unmanned Aerial System, Medium Altitude Long Endurance) management on behalf of the Italian Ministry for Economic Development (MISE).

A company with public and private sector shareholders, CIRA has created three large and unique air and space flying test labs, all built between 1992 and 2002. These leading edge facilities are used by global organizations including Boeing, ESA, and the Chinese Science Academy.

The challenge

CIRA needed to adopt model-based systems engineering methodology and related supporting tools in order to provide an efficient Autonomy Management System for an Unmanned Aerial Systems (UAS) fleet within commercial air traffic constraints. The UAS technologies would have a wide range of applications, including:

- Civil/commercial missions (i.e., environmental and traffic monitoring, detection of infrastructure damages and magnetic fields, inspection of historical monuments)
- National security missions (disaster prevention and supporting rescue operations)
- Scientific and research missions (climate and air pollution monitoring)

The software applications for the UAS-MALE management would be incorporated over an Integrated Modular Avionics (IMA) onboard platform, and the CIRA research methodologies and tools would have to verify and validate these applications for electronics on Unmanned Aerial Systems (UAS) used on missions monitoring and controlling national territories.

To accomplish this, CIRA planned to implement two new software systems: a Flight Management System (FMS) and a Health Management System (HMS). These would be tightly interconnected in order to provide an efficient Autonomy Management System for a UAS. These systems would also collaborate and interact with several external actors in order to let the UAS independently and correctly execute missions. Adopting these systems and a model-based systems engineering methodology would enable CIRA software designers to efficiently apply object-oriented technologies and by using SysML and UML standard modeling languages there would be a more effective spread of CIRA's results.

The solution

After an in-depth evaluation of all leading tool offerings on the market, CIRA issued a public invitation for a SysML and UML modeling tool supporting system and software development processes. During the evaluation process, it became increasingly evident to CIRA that PTC Integrity™ Modeler™ aligned with their technical specifications and would improve the quality of their overall systems engineering methodology. They were also interested in avionics certification with DO-178/DO-254. The combination of the best tool and the best certification skills drove CIRA to choose PTC.



PTC Integrity Modeler in action

CIRA is using PTC Integrity Modeler to formally describe complex software system behavior with UML diagrams and elements, and have adopted a Use Case driven approach. This methodology rapidly and easily highlights ambiguous issues in the early design stages. The FMS and HMS system complex behaviors are represented with Use Case diagrams and scenarios are elaborated based on High Level Requirements (HLR). The traceability from UC to HLR is maintained with SysML requirements relationships and shown on PTC Integrity Modeler requirements diagrams. The detailed scenarios of FMS's and HMS's behaviors are modeled using sequence diagram, showing the signals exchanged with their actors and data structures.

CIRA takes advantage of PTC Integrity Modeler's internal configuration management features by creating baselines of models and concurrently working on model branches. Requirements hyperlinks in Use Case description text fields are used extensively to show requirements coverage. CIRA also benefits from PTC Integrity Modeler's automatic documentation generation and PTC Integrity Modeler Reviewer's readily available model checks.

PTC Integrity Modeler is also used to exchange data with CIRA's DOORS® databases in order to maintain full traceability between requirements and design artifacts. This keeps the two environments fully synchronized, automatically generating the required documentation. This could not be achieved efficiently without PTC Integrity Modeler.

The results

"By implementing PTC Integrity Modeler, our engineers can work on requirement, system, and software elements using the same model at the same time," says Gabriella Gigante, a researcher at CIRA's Softcomputing Lab. "This dramatically improved the quality of our work and reduces the effort taken to keep artifacts consistent all through the design life-cycle. The benefits are very hard to calculate numerically, but we believe that we are gaining valuable results in terms of reduction in the design costs due to an early detection and fixing of the problems during the analysis phase."

"We now plan to leverage our PTC Integrity Modeler modeling skills to handle the new model-based approach included in PTC Integrity Modeler's UML extension profiles for ARINC 653," continues Gigante. "This enables model-based module, partition, application, and communication architecture design, leading to the automated generation of ARINC 653 configuration XML, plus the necessary startup code for VxWorks 653 RTOS. We also plan to spread the use of PTC Integrity Modeler into other projects."



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