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PLC-driven electronic design for the next generation of Astronomical Ground-Based Instrumentation and its integration in a concurrent engineering environment

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Introduction

The implementation of Programmable Logic Controllers (PLCs) has become the new standard for projects funded by the European Southern Observatory (ESO). The industrial approach is key in defining a robust and reliable standard for the control of instrumentation that is ever-growing in size and complexity.

An example is the use of dedicated PLC modules for the management of hazards to the safety of humans, allowing a full integration of safety related functions in the control system. This solution allows not only an easy communication within the PLC network, via fieldbus protocols, but also to share information between multiple systems controlled by different PLCs, without any physical connection.

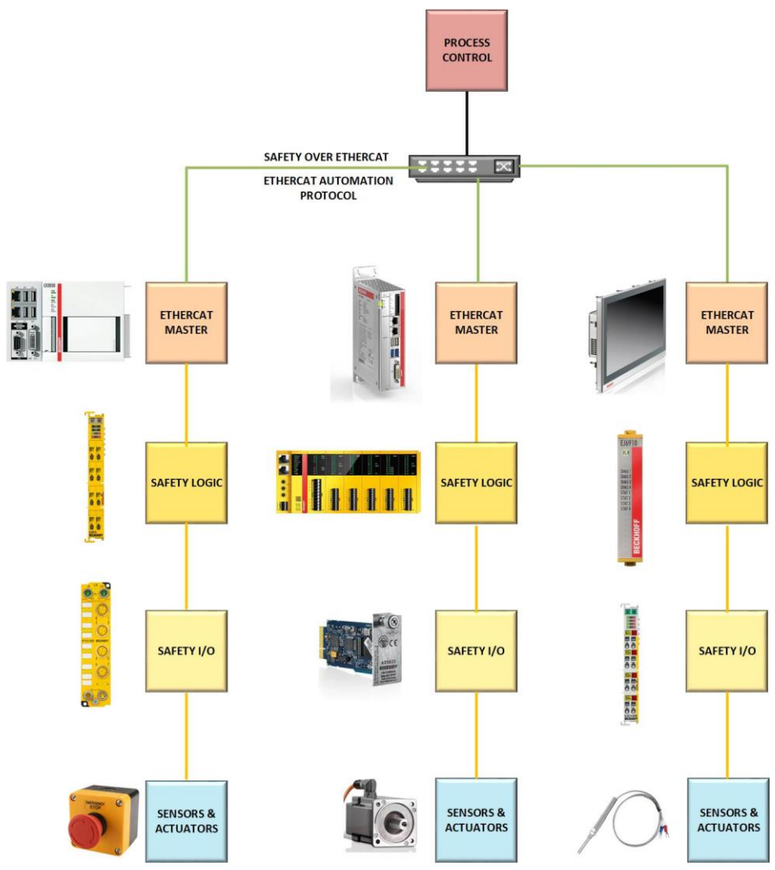

Figure 1. Safety related communication between different PLC networks.

The exploitation of the features offered by a PLC-based solution is an important factor for the definition of an instrument control hardware architecture. However, in order to properly address the intricacies and the increasingly difficult challenges posed by the system as a whole, a change in the paradigm of the astronomical instrumentation design process itself could be required.

Concurrent engineering

In this sense, the concurrent engineering approach, successfully used in other fields, like space related applications, can be also adopted and tailored for the development of the current and future class of ground-based instrumentation. All teams work closely with each other in a dedicated environment, with the aim of efficiently manage the dependencies between subsystems and the phases of the project.

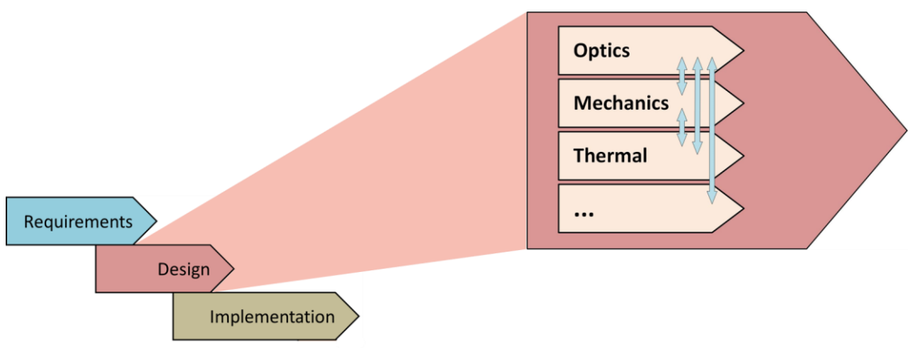

Figure 2. Relationships between phases of the project and subsystems.

Concurrent engineering methodology

The concurrent engineering sessions take place in a Concurrent Design Facility (CDF), specifically equipped to ensure effective collaboration among teams. Each field expert uses their preferred software to conduct their work, with inputs and outputs of the subsystems design being shared via a concurrent engineering tool, updating the system model in an iterative process.

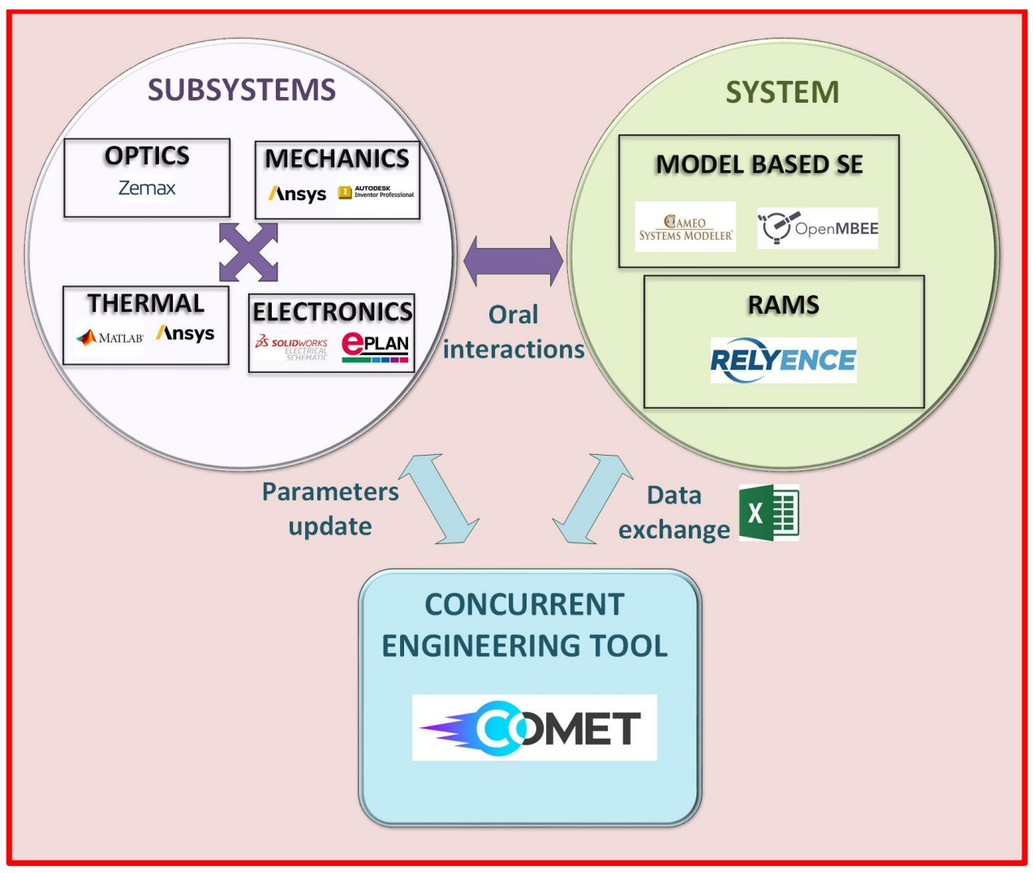

Figure 3. Scheme of a concurrent engineering session.

eXtended Reality

The use of technologies in the eXtended Reality (XR) field can be integrated in the concurrent engineering process.
The XR environment allows to inspect and manipulate complex 3D models, enabling detailed examinations of components, interfaces and potential issues. This immersive experience helps to identify design flaws and possible criticalities during various phases of the assembly, integration and operation of astronomical instrumentation, that would not be as easily found during a standard design review process.

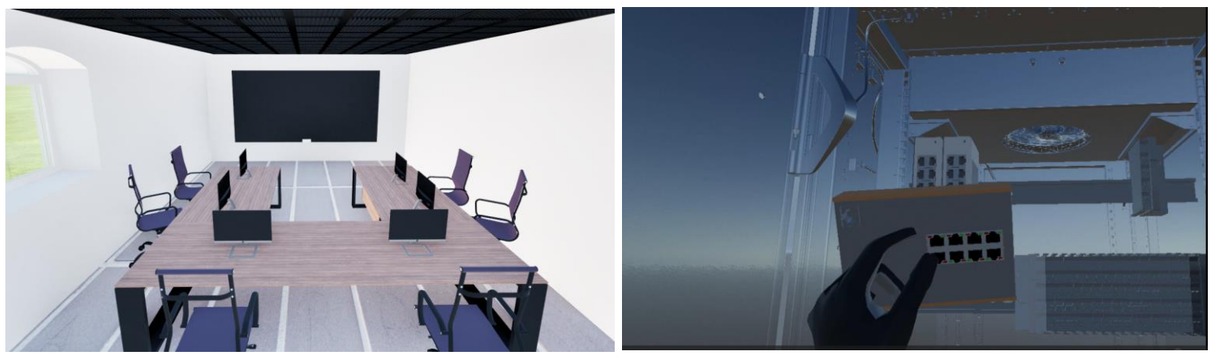

Figure 4. On the left: CDF in virtual reality. On the right: interaction with electronics cabinet in mixed reality.

Output of Mini-Grant activities

This research helped guide the design process of the Naples CDF at the Astronomical Observatory of Capodimonte, as part of the PNRR project "STILES - Strengthening the Italian Leadership in ELT and SKA".
The results of the research activities were shared with multiple publications and oral presentations at various international events, including the SPIE Astronomical Telescopes + Instrumentation 2024 Conference in Yokohama, and the 11th International Systems & Concurrent Engineering for Space Applications Conference in Strasbourg.

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