Implementation and development of a unified systems engineering methodology for design of ITER diagnostic systems

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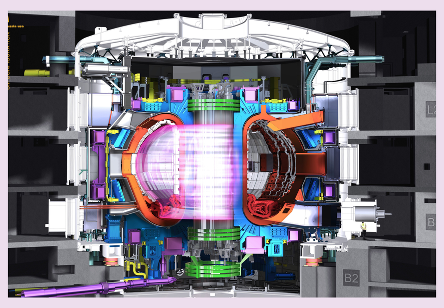
Introduction

- ITER is an international project with involvement of EU, Japan, Russia, USA, China, South Korea and India – altogether 35 nations.
- Based on Deuterium-Tritium plasma, it will be the largest experimental fusion reactor in the world.
- It will generate 500 MW of fusion power with output to input ratio Q > 10.
- The diagnostic systems ('the eyes and ears of ITER') will be used to gather data and provide insights into the behavior, characteristics, and performance of the plasma
- In the scope of diagnostic Instrumentation and Control (I&C) engineers will design, develop and operate diagnostic systems that will provide the measurements necessary to control, evaluate and optimize plasma performance
  - Real-time data gathered with I&C will enable the operators to adjust the plasma's parameters for optimal performance
- Archived data will be analysed offline to support further understanding of plasma physics
- More than 50 diagnostic systems will be used, including following groups:
  - Magnetic diagnostics
  - Neutron diagnostics
  - Optical diagnostics
  - Bolometric systems
  - Spectroscopic instruments
  - Microwave diagnostics
  - Plasma-facing and operational diagnostics



Motivation for a unified systems engineering methodology

Due to the complexity of ITER diagnostic systems, a unified systems engineering methodology for design of diagnostic systems has been adopted owing to the following main factors:

PEOPLE FACTOR

- Many stakeholders are involved in the plasma diagnostics such as owners, designers, suppliers, operators, etc., each with their own engineering culture, methods and tools.
- Communication and coordination are not easy tasks, and rigorous and effective approaches are needed, to ensure consistency among the different stakeholders from domestic agencies and contractors located all over the world.

TIME FACTOR

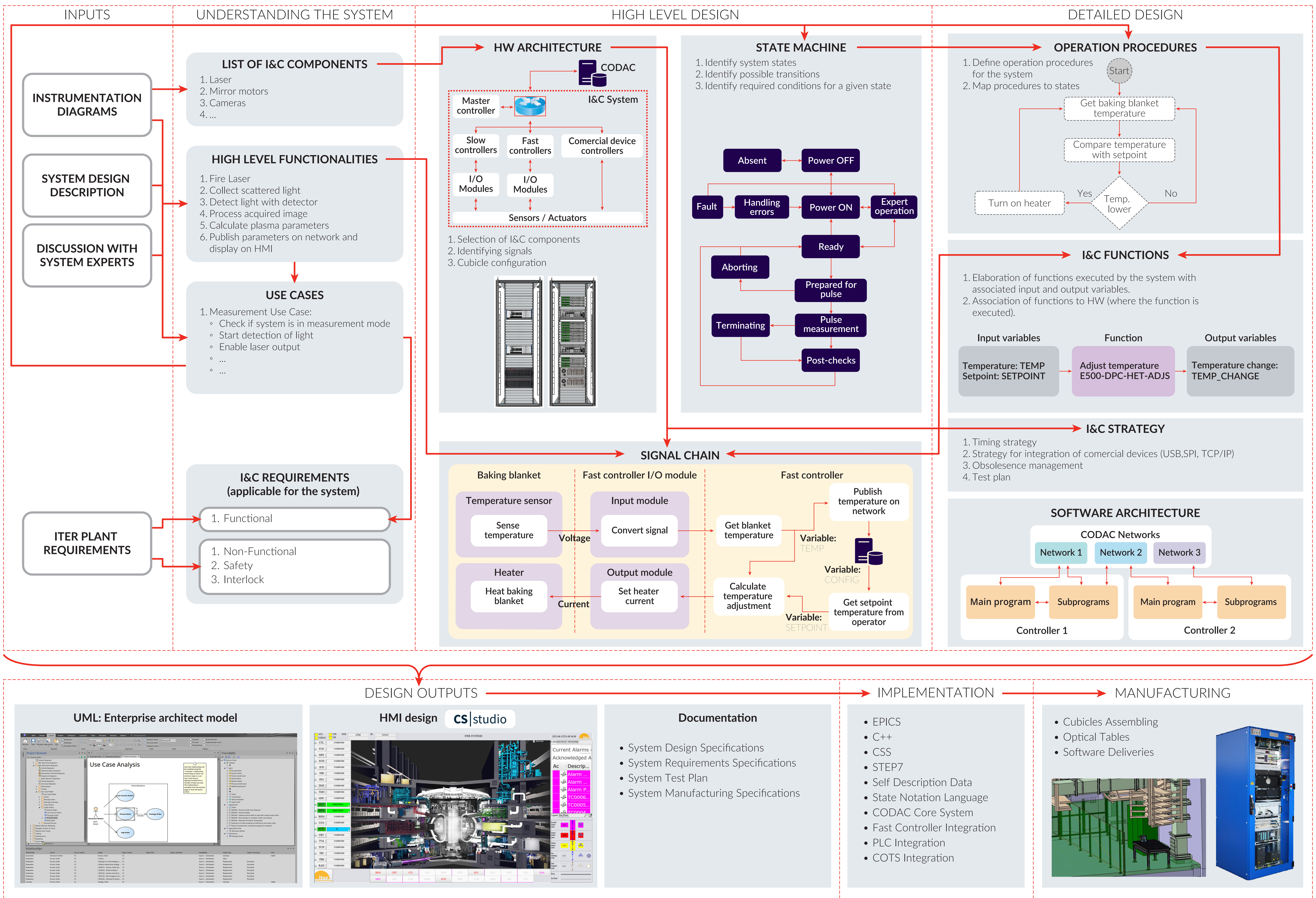
- A lot of time can pass between initial conception and final design, during which a lot of people, technologies and market-related changes can take place; therefore, consistency and traceability of information needs to be ensured across time.
- A robust mechanism is needed which is flexible to updates during the project timeframe.

OPERATIONAL FACTOR

- The aim is to maximise extent of operations automation, and a framework is needed which will allow also non-systems specialists to monitor and control the different diagnostic systems.
- the outputs should be readable even to the small group of operators who will oversee the automated processes.

Thus, a framework is needed which brings together the various stakeholders, design, maintenance and operational resources into a team-based approach to system implementation; the unified systems engineering methodology adopted for design and implementation of ITER diagnostic systems provides exactly this framework.

Diagnostic I&C design methodology



Conclusions

- The presented methodology enables us to get from the design inputs to the functional system via unified steps and checks that ensure completeness and quality of the design content.
- After applying this methodology to several diagnostic systems, Cosylab has been able to strengthen interfaces between the disciplines of systems engineering, architecture and design, and project management, in the domain of fusion-specific developments.
- Cosylab now has in place collocated teams to maximize efficiency, each team dedicated to working on a) System design, b) HW and SW architecture and c) CODAC (Control, Data Access and Communication).
- Cosylab works with system specialists to define and produce the minimum required list of inputs before kicking off design activities.

Adoption of this methodology results in faster, safer and more efficient decision making and can avoid late design changes, which translates to successful projects and more efficient operation. Although this methodology was developed for a nuclear facility like ITER other research laboratories may also significantly benefit from its use.