THE INTEGRATED CONTROL SYSTEM AT ESS

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Abstract

The European Spallation Source (ESS) is a high current proton LINAC to be built in Lund, Sweden. The LINAC delivers 5 MW of power to the target at 2000 MeV, with a nominal current of 62 mA. The project entered Construction phase on January 1st 2013. In order to design, develop and deliver a reliable, well-performing and standardized control system for the ESS facility, the Integrated Control System (ICS) project was established. The ICS project also entered Construction phase on January 1st. ICS consists of four distinct Core components (Physics, Software, Hardware and Protection) that make up the essence of the control system (CS). Integration Support activities support the stakeholders and users, and the Control System Infrastructure provides the required underlying infrastructure for operating the control system and the facility. The current state of the control system project and key decisions are presented as well as immediate challenges and proposed solutions.

STATE OF ESS

With the completion of the Technical Design Report (TDR) [1] ESS has successfully proposed a feasible design for the machine, but the TDR itself is not sufficient to serve as a fixed technical baseline, since there are many non-technical factors influencing the execution of the project, e.g. budget limitations, etc.

These dynamics have to some extent been reflected in the reorganisation of the ESS in the first half of 2013. The most important change at ESS is the arrival of the new CEO Jim Yeck who succeeded Colin Carlile on April 1st, 2013. With his arrival, the internal line structure of the organisation has been changed resulting in ICS becoming a Division within the Machine Directorate.

At the same time the CEO called for an extensive project review in November 2013, to evaluate the readiness of the project for the breaking of ground scheduled for July 2014. The real start of Construction phase will begin as actual builders start construction of Conventional Facilities.

In parallel the activities related to Expressions of Interest (EOI) [2] are ongoing, soliciting countries, institutes and private entities to become possible collaborators and contributors to the ESS project.

STATE OF ICS

Within the ESS project ICS has in the past 2 years performed many reorganisations and restructuring, primarily because of constant increase in scope, responsibility and project visibility.

ICS Organisation

The result of the ESS internal reorganisation is the promotion of the ICS to a Division, yielding the creation of four internal groups within the line structure of ICS.

- **Software and Services group** is responsible for developing the required software and services that makes the control system core.
- **Hardware and Integration group** is responsible for developing and maintaining the standardised HW platform and performing the required integration efforts.
- **Protection Systems group** is responsible for the two critical systems: Machine Protection System(MPS) [3] and Personnel Protection System(PPS).
- **Control System Infrastructure group** is responsible for all the underlying CS infrastructure, e.g. CS Networks and the high-level user-interfacing infrastructure, e.g. the Control Room.

The above structure tries to establish a proper context to cover the core competencies required to develop and deliver the ICS. It's purpose is to make sure the ICS has the required resources and skills within the team.

ICS Project Structure

Orthogonal to the line organisation is the project structure of the ICS, which tries to follow the fundamental service orientation of the ICS project. The main Work Packages (WP) are:

- **High-level applications** WP covers all the graphical (and non-graphical) interfaces to ICS users, including the RF Sources, Cryogenics, Cooling Water, Vacuum, Beam Instrumentation and Beam Physics users etc.
- **CS Software Core** WP covers the development of the required software, e.g. Configuration Management Databases and the development, deployment and maintenance of the required services, e.g. the Alarm handling tools (BEAST [4]), the Archive tools (BEAUTY [5]) etc.
- **CS Hardware Core** WP covers the development, deployment and support of the standardised HW platform(s) [6] and the global ESS Timing System [7, 8].
- **Protection Core** WP covers the two crucial elements of ICS: the MPS and PPS.
- **CS Infrastructure** WP covers all the required CS infrastructure.

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- **Integration Support** WP encapsulates all the required efforts for integrating the stakeholder systems into ICS

The first five WPs are the core packages providing the vital functionalities of the CS whereas Integration Support is the WP providing the connections between ICS and stakeholders. The project's role is to provide structured work and tasks to ICS team members. A WP is lead by a WP Leader, a responsibility for the integration of a system, e.g. the Ion Source is delegated to a system Lead Integrator.

Roles and Responsibilities

In order to guarantee the two most crucial elements: well defined, developed and standardised core components and stakeholder support, the roles and responsibilities related to Core Component development and Integration Support must be well defined and clear.

The optimum approach seems to be a matrix structure shown in Fig. 1, where the Core WP leaders have the horizontal axis responsibilities, and the Lead Integrators have the vertical system integration responsibility and are considered as users of the Core services, e.g. the Timing service.

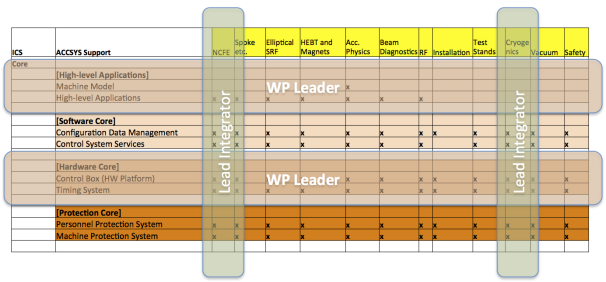

Figure 1: The structure of roles, responsibilities and the interfaces.

Short and Mid-term Plans

As far as planning activities for ICS, there is one critical milestone: by March 2017 an **ICS Vertical Slice test** must be performed and passed. This requires that the entire vertical ICS structure, from the stakeholder system to high-level applications and all intermediate service and layers must be operational and functional without serious issues and bugs.

In order to achieve this, there are three steps in the plan, the first two being critical:

- **Short term:** by the end of 2014 the ICS internal project structure and the team structure must be established, staffed and fully operational. There are at least 2 test stands coming online in 2014 providing good testing grounds for the ICS setup and strategy. The goal is to establish the strategy, procedures and teams with core competencies to handle the peak loads during the 3-5 future years.

- **Mid term:** from the beginning of 2015 to to the end of 2016 the majority of Core components must be designed, developed, deployed and tested in order to have an operational system to perform the Vertical Slice tests. The focus in this period is the development and testing of components and services.

- **Long term:** from mid-2017 onwards the majority of Core components must be operational to support Accelerator commissioning, etc. The main emphasis in this period is on installation and commissioning of devices.

STRATEGIES, PROCEDURES AND DECISIONS

The peak loads approaching in the mid-term plans cannot be handled without appropriate strategies and procedures. And such cannot be enforced without decisions.

Early Development and Standardisation Strategy

The ESS machine will be decommissioned in 2065 enforcing an operational requirement on ICS to function for almost 50 years. Such a timespan makes it unfeasible to commit to a single HW platform so early in the project. Therefore, ICS has adopted the following approach, allowing more agility:

1. Evaluate available technologies and platforms
2. Choose the technology and platform meeting current stakeholder and system requirements
3. Standardise the technology / platform and make it available as a service
4. Repeat the process in case stakeholder requirements change

Such an approach allows ICS to offer the integration services to many stakeholders across ESS early (because of available technology choice) and at the same time establishes a good standardised technology or platform baseline.

Integration Support, Control Boxes, Shopping List

The procedures how the technologies, platforms or components are chosen are strictly controlled by the Shopping List procedures allowing stakeholders to be included in the selection process. At the same time this enforces certain requirements on the process, such that the resulting choice is fully supported and available to any interested stakeholder as a platform or service. Complementing this are the Integration Support efforts ICS is offering so that ICS provides a full integration service to stakeholders. See [9] for the description of the processes.

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Agile ICS

For the Software Core components of ICS and the High-level applications a similar agile approach is being applied in the form of the Scrum development process [10]. Such an approach allows the developers to start with the development early, trying to meet the initial stakeholder requirements and improves the product or service as the stakeholder requirements get better and more refined.

The second benefit of such approach is to bring the stakeholders closer to the development team and the development process which makes collaboration with external groups and divisions much easier and more efficient. More on the ICS Agile approach on the SW development can be read in [9].

CURRENT AND FUTURE CHALLENGES

Although there were already many decisions made and strategies approved, the current and future challenges that ICS has to tackle every day are not eliminated. We list some of those ongoing challenges and responses below.

Non-committed Users

The long time-frame for development of the majority of stakeholder systems (delivery in 2017+) has as a consequence stakeholders that are not forced by the short time frame to commit to any of the requirements, opting for the freedom of choice and possibly, the gold-plated system approach.

This is countered from ICS by soliciting requirements from stakeholders and meeting them with available technologies and platforms. This is making it harder to justify possible shifts in direction and modification of requirements later in the development process due to already working systems and available platforms.

The Architecture of ICS

Although the CS architecture follows the three-tier model, it is hard to finalise the complete ICS architecture (and the structure of internal layers, e.g. High-level applications) due to constant changes in project scope, responsibilities and organisation.

In addition, ICS is committed to deliver a well developed and supported Machine Model as a service to users, and it is not trivial to fit such a service (and it's capabilities) into a coherent ICS architecture.

Availability and Reliability

The ESS facility is committed to high-availability (at least 95% [11]) which can have significant impact on the design of services, choice of hardware, procedures and support, etc. Although at the moment it is not clear which requirements this has for ICS, there is a feasible risk that such requirements without clear validation and verification plans can result in budget and time overruns.

CONCLUSIONS

The ESS organisation has acknowledged the role and importance of the ICS project with the latest reorganisation. As such, this has given the ICS project the power and authority to fully commit to the plans, strategies and decisions prepared and taken. There are still issues to overcome, from heavy staff ramping in the next years and core competencies building to budget cuts and possible scope creep, but with support of the program the goals and milestones seem at last reachable.

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