EUROPEAN SPALLATION SOURCE
Integrated Control System (ICS) - overview

Accelerator Schedule Review for Normal Conducting Linac (NCL)

HECTOR NOVELLA (DEPUTY PROJECT MANAGER, ICS) ON BEHALF OF A CAST OF 90

2020-02-04
Outline

1. An overview to the Integrated Control System
2. Technical components in relation to the Normal Conducting Linac (NCL)
3. Summary
Overview

Integrated Control System (ICS)

Organization

- ICS is responsible for the control systems within the ESS facility, including the accelerator, target station, neutron scattering systems and conventional facilities. Moreover, it provides machine protection and personnel safety systems.

- ICS division has four domain competence groups:
  - Control System Infrastructure Group
  - Control System Software Group
  - Hardware and Integration Group
  - Protection Systems Group

Project scope, main work packages in relation to the NCL

- Software Core (Controls Configuration DB,...)
- Physics applications and on-line model
- Hardware (timing, data acquisition, firmware, standardization)
- Control System Infrastructure (data centres, technical networks, control rooms)
- Machine Protection System
- Personnel Safety System
- CS integration for the Accelerator systems:
  - RF: power supplies, klystrons, modulators
  - Beam Instrumentation
  - ISrc, LEBT, RFQ, MEBT, DTL, vacuum, cooling
Facility supervision and integration

- Use of EPICSv7 family of distributed control system software to realize a homogeneous facility integration layer for all ESS systems relevant to neutron production and usage.

Timing System

- To provide high-precision synchronization of the distributed control systems to achieve a coordinated operation of the accelerator, target and neutron instruments.
- The timing system is synchronised to the accelerator power sources. It broadcasts operational data, time stamps and trigger events to a large number of receivers simultaneously with a deterministic nano-second accuracy.

Software services

- To developers, operators and users for operational and maintenance.
- Graphic user interfaces for operation, machine data analysis and archiving, equipment configuration, calibration and maintenance.

Control room facilities

- Environment and equipment for operators, scientists and engineers for interaction with ESS systems.

Networks and infrastructure

- Technical Network, centralized computing resources and data storage facilities for the operation of ESS systems.
Process and device control systems

- “Process” refers to control or monitor physical processes, such as: cooling systems, electromagnetic systems or ventilation systems. Where the process control function is usually realized with industrial automation technology.

- “Device” relates to physical phenomena, such as: proton beam diagnostics, experimental sample conditioning or neutron detector systems. Often realized as customized high performance control systems.

Personnel Safety Systems

- To identify, analyze, and mitigate against the facility’s prompt ionising radiation hazards, as well as other hazards such as high voltage, magnetic fields, lasers, motion controls and oxygen depletion.

Machine Protection Systems

- Protect the equipment.
- Protect the beam.
- Provide evidence.
Level 1 milestones represent finalization of significant deliverables from the construction phase.

It also signifies the transition of ICS staff from the construction phase to initial operations.

This transition is carefully planned and cost estimated in the 2018 baseline plan.
Key integration milestones
2018 baseline in relation to ICS - AccSys

2018

MS L1: ICS components ready for initial operations independently
21/12/2018

2019

MS L1: ICS ready for Accelerator ready for BoD
30/11/2020

2020

MS L1: ICS ready for Target ready for BoT
13/01/2022

MS L1: ICS ready for Test beamline and Bunker ready for hot commissioning
31/05/2022

2022

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1b: RF Cell and LLRF Control ready</td>
<td>4/2/2019 - 1/4/2019</td>
</tr>
<tr>
<td>L1b: PSS-1 validation start</td>
<td>17/6/2019 - 12/7/2019</td>
</tr>
<tr>
<td>L1b: SRR #2 - Beam through RFQ + MEBT (and DTL1)</td>
<td>19/8/2019 - 11/10/2019</td>
</tr>
<tr>
<td>L1b: PSS-1 re-validation start</td>
<td>16/12/2019 - 31/1/2020</td>
</tr>
<tr>
<td>L1b: SRR #3 - Beam through DTL1-4</td>
<td>1/3/2020 - 24/4/2020</td>
</tr>
<tr>
<td>L1b: PSS-Accelerator complete</td>
<td>7/9/2020 - 9/10/2020</td>
</tr>
<tr>
<td>L1b: SRR #4 - Beam through DTL5 to DMPL</td>
<td>2/11/2020 - 11/12/2020</td>
</tr>
</tbody>
</table>
Networks and infrastructure

ICS – technical components

The logical network topology is in the form of a collapsed spine leaf with core and access layer.

Two main routes with H01 and D02 as core.

**Network installation**

- **Design, planning and later on installations of fiber and copper outlets in D & E buildings**
- **Fiber and copper installations in main server room in H01.**
- **Intra-site fiber between H01 and G02/G04.**
- **Optical fiber in G04 & G02 CXB for:**
  - Cryo (ACCP, TMCP, TICP)
  - ODH
- **Fiber and copper installations in ailes in G02 Klystron Gallery.**
  - 23 ailes with 10 500 copper connections and 1 100 fiber connections.
- **Finalize G02 TS2 installation with copper between the racks.**
  - 130 copper connections.
- **Optical fiber and copper for Technical Network in FEB level 90.**
Process control system integration (1/2)

ICS – technical components

ISrc+LEBT

- In-kind contribution (CEA, France) which needed numerous modifications and additional work to align with ICS conventions or standards, including re-assembly of many components.

RFQ

- Control systems for RF subsystems such as LPS FIM, SIM, SSA, ...and Vacuum, LLRF, water cooling, temperature monitoring, etc.
MEBT

- In-kind contribution (Spain) with ICS support beyond original scope. Special focus on instrumentation:
  - Wire Scanners
  - Emittance Measurement Units
  - Longitudinal Bunch Monitor
  - Neutron Beam Loss Monitors
  - Non Invasive Profile Monitors
  - Beam Current Monitors
  - Beam Position Monitors
  - Scrapers
  - Faraday Cup

DTL

- Control systems provided by an in-kind partner (INFN_LNL, Italy) with support from ICS.
- Main control systems relate to cooling systems and RF cavities.
Machine Protection System - goals
ICS – technical components

1. Enable highly flexible operation of ESS,
2. Enable & increase proton and neutron beam availability (by preventing and mitigating damage to the machine)

How?
- Through the use of:
  - Interlocks
  - Data exchange
- By applying a modular design:
  - Inputs grouped according to equipment type (magnets, vacuum valves, beam current monitors, etc.)
  - Inputs grouped according to relevance (based on beam destination)

![Diagram of machine protection system](image-url)
Machine Protection System - architecture

ICS – technical components

Fast Beam Interlock System (FBIS):

- **collects inputs** (RF, Beam Monitoring, Vacuum, etc)
- **decides if it is safe** to operate with beam or not.
- **interrupts** beam operation in case of a fault.

BCM: Beam Current Monitor
BLM: Beam Loss Monitor
nBLM: Neutron BLM
icBLM: Ionisation Chamber – BLM
BPM: Beam Position Monitor
FBIS: Fast Beam Interlock System
FC: Faraday Cup
FSU: Fast Shutdown Unit
Isrc: Ion Source
LPS: Local Protection System
LPSRSM: LPS for Raster Magnets
MPS: Machine Protection System
MPSID: MPS for Insertable Devices
MPSMag: MPS for Magnets
MPSTrg: MPS for Target
MPSVac: MPS for Vacuum
RF: Radio Frequency System
Personnel Safety System for NCL (PSS1)
ICS – technical components

PSS1 is realised in three phases:

- PSS1-a: ISrc up to and including RFQ (required for RFQ RF conditioning) → 2020-05-31
- PSS1-b: ISrc up to and including DTL1 (required for DTL1 RF conditioning) → 2020-09-28
- PSS1-c: ISrc up to and including DTL4 → 2021-04-05

What should be installed, commissioned and validated for PSS1-a?
- PSS1 PAS & MAS (including card readers connected to ESS access control system, intercom, CCTV);
- PSS1 fences (e-exits, zone gate);
- PSS1 interfaces with TSW;
- PSS1 key exchange system;
- PSS1 field devices (Emergency switch-off stations, doors switches, lights, etc.) for the whole PSS1 controlled area;
- PSS1 interfaces with REMS (x5);
- PSS1 interfaces with ISrc;
- PSS1 interfaces with RFQ RF system.

To be added for PSS1-b:
- PSS1 interfaces with MEBT RF system (x3);
- PSS1 interfaces with DTL1 RF system.

To be added for PSS1-c:
- PSS1 interfaces with DTL2, DTL3 and DTL4 RF systems.
ICS is used for three purposes:
- Technical: control and communication systems at ESS
- Organizational: the ICS division
- Managerial: the ICS sub-project

The main technical components in relation to Normal Conducting Linac are:
- Control System Infrastructure
- Personnel Safety System (PSS)
- Machine Protection System (MPS)
- ISrc+LEBT integration into ICS
- RFQ integration into ICS
- MEBT integration into ICS
- DTL integration into ICS

On Wednesday, 5 February we will discuss for each of those systems about:
- Current status of the works
- Schedule risks and threats
- Dependencies
- etc...