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# SCOPE

The systems engineering management plan (SEMP) is the top-level plan for the Integrated Control Systems (ICS) division to tailor the ICS life cycle integration strategy to the Cryomodule and Cryodistribution Control System (C3S) of the LINAC. The SEMP gives a comprehensive overview on a specific system. The SEMP defines the scope of the controls integration and how the ICS effort will be structured, conducted, monitored and completed through each of the life cycle stages. Additional information about required reviews and their completion criteria as well as references to all ICS project documents are defined or listed in the SEMP.

This document is issued by the European Spallation Source (ESS), ICS Division, Hardware and Integration Group.

# GOAL AND SCOPE FOR THE C3S

## General Goal

The goal of the C3S is to provide control, data logging, display and alarm functionality of the accelerator helium cooling system to the ESS Facility according to the ICS Handbook [1] and ICS Integration Strategy [2].

## ICS Scope of C3S

The ICS scope is the design, configuration and commissioning of the control system hardware, Programmable Logic Controller (PLC) logic, EPICS Input Output Controller (IOC), OPerator Interface (OPI), data archiving and alarm handling. The term C3S is a collection of control systems for the cryogenic-distrubution and for the cryogenic modules in the ESS Linac, which includes the following systems with FBS codes:

Table 1: System Names & Numbers

| System Name | FBS |
| --- | --- |
| Cryogenic Distribution System (CDS) – End Box - Control System | =ESS.ACC.W07.W04.Q001.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 01 - Control System | =ESS.ACC.W07.W04.Q002.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 02 - Control System | =ESS.ACC.W07.W04.Q003.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 03 - Control System | =ESS.ACC.W07.W04.Q004.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 04 - Control System | =ESS.ACC.W07.W04.Q005.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 05 - Control System | =ESS.ACC.W07.W04.Q006.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 06 - Control System | =ESS.ACC.W07.W04.Q007.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 07 - Control System | =ESS.ACC.W07.W04.Q008.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 08 - Control System | =ESS.ACC.W07.W04.Q009.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 09 - Control System | =ESS.ACC.W07.W04.Q010.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 10 - Control System | =ESS.ACC.W07.W04.Q011.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 11 - Control System | =ESS.ACC.W07.W04.Q012.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 12 - Control System | =ESS.ACC.W07.W04.Q013.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 13 - Control System | =ESS.ACC.W07.W04.Q014.K01 |
| Cryogenic Distribution System (CDS) – Spoke Linac Valve Box 14 - Control System | =ESS.ACC.W07.W04.Q015.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 15 - Control System | =ESS.ACC.W07.W03.Q001.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 16 - Control System | =ESS.ACC.W07.W03.Q002.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 17 - Control System | =ESS.ACC.W07.W03.Q003.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 18 - Control System | =ESS.ACC.W07.W03.Q004.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 19 - Control System | =ESS.ACC.W07.W03.Q005.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 20 - Control System | =ESS.ACC.W07.W03.Q006.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 21 - Control System | =ESS.ACC.W07.W03.Q007.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 22 - Control System | =ESS.ACC.W07.W03.Q008.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 23 - Control System | =ESS.ACC.W07.W03.Q009.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 24 - Control System | =ESS.ACC.W07.W03.Q010.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 25 - Control System | =ESS.ACC.W07.W03.Q011.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 26 - Control System | =ESS.ACC.W07.W03.Q012.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 27 - Control System | =ESS.ACC.W07.W03.Q013.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 28 - Control System | =ESS.ACC.W07.W03.Q014.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 29 - Control System | =ESS.ACC.W07.W03.Q015.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 30 - Control System | =ESS.ACC.W07.W03.Q016.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 31 - Control System | =ESS.ACC.W07.W03.Q017.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 32 - Control System | =ESS.ACC.W07.W03.Q018.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 33 - Control System | =ESS.ACC.W07.W03.Q019.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 34 - Control System | =ESS.ACC.W07.W03.Q020.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 35 - Control System | =ESS.ACC.W07.W03.Q021.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 36 - Control System | =ESS.ACC.W07.W03.Q022.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 37 - Control System | =ESS.ACC.W07.W03.Q023.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 38 - Control System | =ESS.ACC.W07.W03.Q024.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 39 - Control System | =ESS.ACC.W07.W03.Q025.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 40 - Control System | =ESS.ACC.W07.W03.Q026.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 41 - Control System | =ESS.ACC.W07.W03.Q027.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 42 - Control System | =ESS.ACC.W07.W03.Q028.K01 |
| Cryogenic Distribution System (CDS) – Elliptical Linac Valve Box 43 - Control System | =ESS.ACC.W07.W03.Q029.K01 |
| Cryomodules SPK - Spoke Linac SPK010 - Control System | =ESS.ACC.A03.A02.XX01 |
| Cryomodules SPK - Spoke Linac SPK020 - Control System | =ESS.ACC.A03.A03.XX01 |
| Cryomodules SPK - Spoke Linac SPK030 - Control System | =ESS.ACC.A03.A04.XX01 |
| Cryomodules SPK - Spoke Linac SPK040 - Control System | =ESS.ACC.A03.A05.XX01 |
| Cryomodules SPK - Spoke Linac SPK050 - Control System | =ESS.ACC.A03.A06.XX01 |
| Cryomodules SPK - Spoke Linac SPK060 - Control System | =ESS.ACC.A03.A07.XX01 |
| Cryomodules SPK - Spoke Linac SPK070 - Control System | =ESS.ACC.A03.A08.XX01 |
| Cryomodules SPK - Spoke Linac SPK080 - Control System | =ESS.ACC.A03.A09.XX01 |
| Cryomodules SPK - Spoke Linac SPK090 - Control System | =ESS.ACC.A03.A10.XX01 |
| Cryomodules SPK - Spoke Linac SPK100 - Control System | =ESS.ACC.A03.A11.XX01 |
| Cryomodules SPK - Spoke Linac SPK110 - Control System | =ESS.ACC.A03.A12.XX01 |
| Cryomodules SPK - Spoke Linac SPK120 - Control System | =ESS.ACC.A03.A13.XX01 |
| Cryomodules SPK - Spoke Linac SPK130 - Control System | =ESS.ACC.A03.A14.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL010 - Control System | =ESS.ACC.A04.A02.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL020 - Control System | =ESS.ACC.A04.A03.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL030 - Control System | =ESS.ACC.A04.A04.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL040 - Control System | =ESS.ACC.A04.A05.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL050 - Control System | =ESS.ACC.A04.A06.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL060 - Control System | =ESS.ACC.A04.A07.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL070 - Control System | =ESS.ACC.A04.A08.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL080 - Control System | =ESS.ACC.A04.A09.XX01 |
| Cryomodules MBL - Medium Beta Linac MBL090 - Control System | =ESS.ACC.A04.A10.XX01 |
| Cryomodules HBL - High Beta Linac HBL010 - Control System | =ESS.ACC.A05.A02.XX01 |
| Cryomodules HBL - High Beta Linac HBL020 - Control System | =ESS.ACC.A05.A03.XX01 |
| Cryomodules HBL - High Beta Linac HBL030 - Control System | =ESS.ACC.A05.A04.XX01 |
| Cryomodules HBL - High Beta Linac HBL040 - Control System | =ESS.ACC.A05.A05.XX01 |
| Cryomodules HBL - High Beta Linac HBL050 - Control System | =ESS.ACC.A05.A06.XX01 |
| Cryomodules HBL - High Beta Linac HBL060 - Control System | =ESS.ACC.A05.A07.XX01 |
| Cryomodules HBL - High Beta Linac HBL070 - Control System | =ESS.ACC.A05.A08.XX01 |
| Cryomodules HBL - High Beta Linac HBL080 - Control System | =ESS.ACC.A05.A09.XX01 |
| Cryomodules HBL - High Beta Linac HBL090 - Control System | =ESS.ACC.A05.A10.XX01 |
| Cryomodules HBL - High Beta Linac HBL100 - Control System | =ESS.ACC.A05.A11.XX01 |
| Cryomodules HBL - High Beta Linac HBL110 - Control System | =ESS.ACC.A05.A12.XX01 |
| Cryomodules HBL - High Beta Linac HBL120 - Control System | =ESS.ACC.A05.A13.XX01 |
| Cryomodules HBL - High Beta Linac HBL130 - Control System | =ESS.ACC.A05.A14.XX01 |
| Cryomodules HBL - High Beta Linac HBL140 - Control System | =ESS.ACC.A05.A15.XX01 |
| Cryomodules HBL - High Beta Linac HBL150 - Control System | =ESS.ACC.A05.A16.XX01 |
| Cryomodules HBL - High Beta Linac HBL160 - Control System | =ESS.ACC.A05.A17.XX01 |
| Cryomodules HBL - High Beta Linac HBL170 - Control System | =ESS.ACC.A05.A18.XX01 |
| Cryomodules HBL - High Beta Linac HBL180 - Control System | =ESS.ACC.A05.A19.XX01 |
| Cryomodules HBL - High Beta Linac HBL190 - Control System | =ESS.ACC.A05.A20.XX01 |
| Cryomodules HBL - High Beta Linac HBL200 - Control System | =ESS.ACC.A05.A21.XX01 |
| Cryomodules HBL - High Beta Linac HBL210 - Control System | =ESS.ACC.A05.A22.XX01 |

In case of Cryomodules the “XX01” in FBS are a placeholder characters for objects controlled by the control system of the connected CDS valve box.

# Stakeholders of the C3S

The following stakeholders are identified, see Table 2.

Table 2: Stakeholder identification.

| ID | Stakeholder | Role and Contact |
| --- | --- | --- |
| 1 | Control system development project team for C3S | Project Manager: Wojtek Fabianowski  Technical Leader: Peter Temesvari |
| 2 | Hardware & Integration Group (ICS) | Work Package Manager: Philippe Rabis  Group Leader: Karl Vestin |
| 3 | ICS Management team | Chief Engineer for the ICS Division: Timo Korhonen  Responsible for systems engineering strategy: Thilo Friedrich |
| 4 | Accelerator Systems | Work Package Manger:  Cryogenic System, System Owner: |
| 4 | Accelerator Vacuum Controls | General Responsibility for the ESS vacuum system controls. Contact: |
| 5 | RF System | Responsible for RF System: |
| 6 | Safety and Protection Group (ICS) | Responsible for ESS personnel safety systems (PSS). Contact: |
| 7 | Accelerator Operations and Maintenance Group | Responsible for operations and maintenance of accelerator. Contact: |
| 8 | Environment, Safety & Health | Responsible for ESS-wide environmental, safety and health policies and compliance. Contact: |

# APPROACH FOR TECHNICAL AND MANAGEMENT REVIEW AND REPORTING - SYSTEMs ENGINEERING PROCESS

The integration strategy for the C3S with the ESS EPICS Environment (E3) is based on the defined model in the document ICS Systems Integration Strategy [2].

## Systems Engineering Life Cycle and Reviews

Due to the fact that the installation of the Cryogenic Distribution is in advanced stage it is decised to divide the control system engineering life cycle to the following two main phases:

* 1. phase: Design, development, integration, commissioning of the manual control functions for the Cryrogenic Distribution System (Elliptical and Spoke ValveBoxes, EndBox).
* 2. phase: Design, development, integration, commissioning of the functions for automatic operation modes of the Cryogenic Distribution System and the control functions for (Elliptical and Spoke) Cryomodules. Operation and decommissioning at the end of life cycle.

For a more efficient approach, the requirements and the preliminary design systems life cycle stages of the first phase (see stage ID 1 and 2a in Table 2), has been moved into the Critical (=Detailed) Design life cycle stage. Details are as follows:

Table 3: System Life Cycle Stages and Reviews for the overall C3S

|  |  |  |  |
| --- | --- | --- | --- |
| **Stage ID** | **System Life Cycle Stage** | **Key Documents** | **Review (triggering transition)** |
| **1** | **Requirements** |  |  |
| **2a** | **Preliminary Design** |  | **PDR:** Preliminary Design Review |
| **2b** | **Critical (=Detailed) Design – Manual CDS** | System Engineering Management Plan  System Requirements Document  Concept of Operation  Interface Control Documentation  Detailed Design Documents (Electrical plans and Software System Description)  Verification Plan  System Integration Plan | **CDR#1:** Critical Design Review |
| **3** | **Development – Manual CDS** | Verification Report  Validation Plan | **TRR#1:** Test Readiness Review |
| **4** | **Integration and Test – Manual CDS** | Validation Report  As-Built Detailed Design Documents (Electrical plans and Software System Description) | **SAR#1:** System Acceptance Review |
| **5** | **Early Operation – Manual CDS** | Operation Manual | **ORR#1:** Operational Readiness Review |
| **5** | **Critical (=Detailed) Design – Automatic CDS and Cryomodule functions** | Updated System Requirements Document  Updated Concept of Operation  Updated Detailed Design Documents (Electrical plans and Software System Description)  Updated Verification Plan  Updated System Integration Plan | **CDR#2:** Critical Design Review |
| **6** | **Development – Automatic CDS and Cryomodule functions** | Updated Verification Report  Updated Validation Plan | **TRR#2:** Test Readiness Review |
| **7** | **Integration and Test – Automatic CDS and Cryomodule functions** | Updated Validation Report  As-Built Detailed Design Documents (Electrical plans and Software System Description) | **SAR#2:** System Acceptance Review |
| **8** | **Production (system into operation, resolve problems from Integration and Test Stage)** | Operation and Maintenance Manual | **ORR#2:** Operational Readiness Review |
| **9** | **Operation & Maintenance** |  | *To be updated in Operational Readiness Review #2* |
| **10** | **Disposal (Decommissioning)** |  | *To be updated in Operational Readiness Review #2* |

## Work Breakdown Structure (WBS)

The C3S is a part of the ICS work package 10 (WP10 – Accelerator Integration). The work unit (WU) at ICS is called Cryomodule and Cryodistribution Control System. Please reference the ICS Primavera® P6 work plan for work breakdown, schedule and costing information.

## Procurement Strategy

The C3S will be developed by evopro systems engineering Ltd. commissioned by the ICS Hardware & Integration Group. Under Accelerator Division, in-kind partners are providing the Cryomodules.

# IDENTIFICATION OF TOOLS, METHODS, AND TECHNIQUES

For a successful integration of the system the following standard technical tools shall be used:

* ESS Naming Service
* Controls Configuration Database
* Eplan P8
* PLC Factory
* Siemens TIA Portal
* Control System Studio
* BEAST Alarm Handler
* EPICS Archiver Appliance
* petenv test tool

The ICS Handbook[1] and ICS Integration Strategy [2] provides additional information on tools, methods and techniques.

# Schedule and Costs

The C3S is a part of the ICS work package 10 (WP10 – Accelerator Integration). The Work Unit (WU) at ICS is called Cryomodulue and Cryodistribution Control System. Please reference the ICS Primavera® P6 work plan for work breakdown, schedule and costing information.

# CONTROL SYSTEMS DOCUMENTATION

In alignment with the ICS Systems Integration Strategy[2], ESS templates shall be used for the C3S life cycle documentation and shall be based on the ESS PLM templates. Table 3 lists the documentation of the C3S. The list will be updated during the ongoing project work.

| Table 4 C3S System Documentation | |
| --- | --- |
| Title | Where to find |
| Cryomodule and Cryodistribution Control System – System Engineering Management Plan | ESS-1406553 |
| Cryomodule and Cryodistribution Control System - System Requirement Specification | ESS-1407413 |
| Cryomodule and Cryodistribution Control System - Concept of Operations | ESS-1407416 |
| Cryomodule and Cryodistribution Control System – Electrical Design Drawings | ESS-1527040  ESS-1528336 |
| Cryomodule and Cryodistribution Control System – System Design Document | ESS-1408068 |
| Cryomodule and Cryodistribution Control System – Interface Control Document | ESS-1407417 |
| Cryomodule and Cryodistribution Control System – System Integration Plan | ESS-1407254 |
| Cryomodule and Cryodistribution Control System – Verification Plan | ESS-1408071 |
| Cryomodule and Cryodistribution Control System – Verification Report | ESS-1414568 |

# Glossary

| Term | Definition |
| --- | --- |
| BEAST  C3S  CCDB  CDR  EPICS  ESS  GUI  ICS  IOC  MPS  OPI  ORR  PDR  PLM  PSS  SAR | Best Ever Alarm System  Cryomodule and Cryodistribution Control System  Controls Configuration Database  Critical Design Review  Experimental Physics and Industrial Controls System  European Spallation Source  Graphical User Interface  Integrated Control System  Input Output Controller  Machine Protection System  OPerator Interface, EPICS based GUI  Operational Readiness Review  Preliminary Design Review  Product Lifecycle Management  Personnel Safety System  System Acceptance Review |
| TIA  TRR  WBS  WP  WU | Totally Integrated Automation, Siemens Programming Platform  Test Readiness Review  Work Breakdown Structure  Work Package  Work Unit |

# references

1. ICS Handbook (ESS-0067637)
2. ICS Systems Integration Strategy (ESS-0054678)

# Document Revision history

| Revision | Reason for and description of change | Author | Date |
| --- | --- | --- | --- |
| 1 | First issue for CDR#1 | Peter Temesvari | 2019-09-17 |
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