Interface Management Plan
GENERAL INTRODUCTION

The ESS facility, as a world leading neutron source, is a very complex system of systems, developed by many partners and suppliers in many countries. In order for ESS AB to be successful in integrating all the subsystems and components, it is important to be very strict and rigorous concerning e.g. terminology, definitions and standards, communication of data and information and to clearly define the engineering processes. Communication and traceability of e.g. requirements, vertically and horizontally, throughout the complete system architecture is extremely important for quality and efficiency.

Part of the requirements is induced by the definition of the systems interfaces. As systems delivered by different in-kind contributors and suppliers will interface, it is crucial that an agreed interface specification contributes to the definition of the collaboration agreements and contracts that ESS AB will have to manage during the construction phase. Within this context, it is crucial to rigorously characterise the systems interfaces. The interface management is also a key for successfully phasing various sub projects developed in parallel and a seamless integration activity.
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1. PURPOSE

Interface management is a process to assist in controlling product development when efforts are divided among parties (e.g. institutes, vendors, geographically diverse technical teams) and to define and maintain compliance among products that must interoperate.

This Interface Management Plan supports the execution of the Systems Engineering Management Plan [1] and is applicable to all engineering activities of the ESS construction phase. It encompasses the terminology, the principles, the processes, the outcomes and the roles for the interface management.

2. LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation of abbreviation</th>
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<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
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<tr>
<td>CCB</td>
<td>Change Control Board</td>
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<td>EPL</td>
<td>ESS Plant Layout</td>
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<td>GUI</td>
<td>Graphical User Interface</td>
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<td>ICD</td>
<td>Interface Control Document</td>
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<td>IMM</td>
<td>Interface Man Machine</td>
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<td>PBS</td>
<td>Product Breakdown Structure</td>
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<tr>
<td>SADT</td>
<td>Structure Analysis and Design technique</td>
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<td>SEP</td>
<td>Systems Engineer for a Part</td>
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<tr>
<td>SET</td>
<td>Systems Engineer Team</td>
</tr>
<tr>
<td>TB</td>
<td>Technical Board</td>
</tr>
<tr>
<td>WBS</td>
<td>Work Breakdown Structure</td>
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3. REFERENCES

4. SCOPE

4.1 Interface definition

A systems interface is a meeting point between two systems. Flows of data, energy, force or matter may be exchanged through the interface between the systems. The Figure 1 depicts the seven types of interfaces addressed by this document considering the operator/user as an interacting system with the system of interest.

![Diagram of seven interfaces](image)

Figure 1: The seven interfaces addressed by the Interface Management Plan.

To illustrate the content of the Figure 1, the interfaces between:

- Human/Software may be a Graphical User Interface,
- Human/Hardware may be a lever or ancillary hardware (tooling),
- Hardware/Hardware may be flanges or connectors, and
- Software/Software are e.g. Application Programming Interfaces (API).

4.2 Life Cycle perspective

Interface characteristics could vary during the life cycle. Indeed, the needs for the construction, the operation, the maintenance and the disposal phases may differ. Thus, it is very important to analyse via use cases each phase (e.g. integration with an assembly) to exhaustively specify the systems interfaces.

5. INTERFACE MANAGEMENT PRINCIPLES

5.1 Interface management types

The interfaces are managed at different levels from different viewpoints. The mechanical integration of products in the ESS Plant Layout is one of the interface management activity.
This activity enables the management of potential conflict between products throughout the life cycle (see section above). It also helps to identify potential conflicts between product location and defined zoning (inflammable material and fire risk area, survey clearance). Digital mock-ups will support this interface management orchestrated by the ESS Integration and Design Support Division. Processes, products and roles for this specific management are developed in reference [2].

A complementary activity is the interface management supported by Interface Control Documents. This approach relies on two types of ICDs:

- ICD between two systems, and
- ICD between a single system and one to many unspecified.

The first type – type A2B - doesn’t aim at exhaustively defining the interfaces of the concerned systems but it focuses on their meeting points. It supports efficiently the development of subprojects that requires a phasing and a reduced and well-controlled interaction.

The second type – type A2x - specifies exhaustively the system inputs and outputs for its integration into a bigger system at the exception of its interfaces already specified in one or several A2B ICDs. This document is an essential tool for the Integrated Control System and the Conventional Facilities projects that are service oriented. The draft version of an A2x ICD is an expression of needs from the product designer to the integration responsible officers.

When two large systems interface, an extended A2B document has to be considered. An extended A2B ICD – A2Be – completely specifies the interface from the lowest physical elements (e.g. water cooling system) to the highest logical levels (e.g. an ESS subsystem). To do so, an A2Be references to multiple A2x ICDs related to the lowest physical elements. It also contains information that are valid for multiple subsystems e.g. water coolant characteristics so that it is not necessary to repeat this information in the related A2x ICDs. In this respect, the A2Be ICD is the entry point to a comprehensive view of the numerous interfaces between large systems.

For software related interfaces, Application Programming Interface documents will be developed as well as notices with tutorials. These specifications will describe routines, data structures, classes and GUI specifications.

Templates and examples will support the drafting of these documents. The Systems Engineer Team will help identify the need for interface specification between two systems as the PBS definition progresses.

### 5.2 Working groups

Dedicated working groups will support the establishment of A2B and A2Be interface specification. Each working group is composed of a representative for each concerned system and an editor to be agreed by the two parties.

The ICD editor will report the progress of the interface specification to CCB of the programme for level 1 ICDs. He/She is responsible for ensuring that the developed ICD content satisfies the ESS Management Plans.

For A2x ICD, the system A owner is responsible for the drafting of the document. He/She will be responsible to schedule and chair meetings with stakeholders to develop the interface...
specification. All A2x ICDs will have to be approved by the concerned parties. The system A owner is responsible for ensuring that the developed ICD content satisfies the ESS Management Plans.

5.3 Configuration Management

Interface specifications are under configuration control once released as defined in the Configuration Management Plan [3].

6. HARDWARE INTERFACE CONTROL DOCUMENT CONTENT

An Interface Control Document is the vehicle for communicating comprehensively and unambiguously interface characteristics, for being the common view between the stakeholders and for scheduling the development of the interface specification. The main objective is to define interfaces in order to allow two independent parallel engineering processes. A particular attention has to be paid to restrict the technical content of an ICD to an interface specification, thus the description of the meeting points and the flows through the meeting points in a life cycle perspective.

6.1 Life cycle and operating modes

Interface characteristics may vary according to the operating mode. Thus, for any ICD, it is mandatory:

1. To identify operating modes (e.g. standby, ON, OFF) and life cycle steps (e.g. maintenance, assembly),
2. To assess how each interface characteristic might change throughout the life cycle or for each operating mode.

The assessment of the system behaviour at the interface has to include how this behaviour might impact other interacting systems.

6.2 Interface elements

An interface is at least a set of two elements: a functional flow and a connector. The interface can also contain non-functional flows.

6.2.1 Functional flows

Functional flows are the flows of interest between the systems. They justify the existence of the interface. Functional flows are either unidirectional or bidirectional. They are of several natures:

- **Thermal**: dissipated power by a heating system,
- **Radiation**: flow of energetic particles (protons, neutrons) or radio frequency wave,
- **Mechanical**: a mass to be supported via the interface, handling principles, fastening points, gripping principles,
- **Gas flow**: for compressed air,
- **Electrical**: for powering (regulated, non regulated, AC, DC, power, current, voltage),
- **Data**: any analogic or digital signal,
- **Coolant flow**: cryogenic fluid or water.
6.2.2 Non-functional flows

Non-functional flows are induced by the existence of the interface and may be constraints for the interacting systems (secondary effects). Non-functional flows are of the same nature as the functional flows. For example:

- **Thermal**: dissipated power by electronics to be handled by HVAC,
- **Radiation**: flow of energetic particles (X-Rays, gammas) for shielding design, reflected radio frequency wave,
- **Gas flow**: desorption for vacuum system design,
- **Mechanical**: acceleration constraints related to transportation.

Specifically in an A2x ICD, the concept of non-functional flow may be extended to describe constraints as the cleanliness or temperature limits for product storage.

6.2.3 Connectors

6.2.3.1 PBS allocation

The functional flows are enabled by physical connections between the systems. The connections might be implemented by a set of subsystems e.g. flanges, plugs which must be identified and allocated in the respective parts of Product Breakdown Structure owned by the parties. The ICD will reference the PBS elements involved in the connection. As PBS elements are trace linked to WBS elements, the traceability between the ICD and the WBS is implicit.

6.2.3.2 Connector specification

According to their associated functional flow, the connectors may be of different types that can be classified in several categories:

- **Mechanical**: mechanical concepts, handling equipment, fastening hook, gripping areas, overall dimensions (tolerances, required clearance for assembly or maintenance), planes, surfaces, positioning ancillaries, alignment, flange type, gasket type, position of the different connections, ground surface area, racks (number of U in cabinet, distance between rack and devices),
- **Electrical**: connector nomenclature (e.g. IEC 60320 C14, 50 Ohm BNC, male/female).
- **Fluids**: connector nomenclature, flow direction,
- **Signals**: connector or port nomenclature,

For mechanical specifications, coordinates shall be expressed in the ESS global coordinate system [5] or the local origin used in the specification shall be located in the ESS global coordinate system. The relationship between the axes used in the specification and the ESS global coordinate system axes shall be unambiguous.

When no nomenclature is applicable to the connector, the ICD must contain a visual description (diagram, picture) with dimensions or must refer to a CAD model. For electrical connectors, each pin must be specified and referred to their associated functional flows.

6.3 Interface milestones

The establishment of the ICDs will rely on the process defined in the section 7. This process will go through various milestones corresponding to specific achievements. These milestones will materialize the progress for the ICD definition and has to be captured in the WBS of the stakeholders.
One specific section will depict the milestones for each interface element included in the ICD. The project planners will make sure that these milestones are coherent with the project schedule.

A milestone is achieved when the expected ICD content is approved by the parties and the related CCB as described in [3]. The ICD shall be submitted for review one week before the milestone.

7. INTERFACE SPECIFICATION PROCESS

The ICD establishment to support the interface specification involves several versions used and provided by the stakeholders. This process is depicted by the SADT diagram of the Figure 2.

This process includes identifying and defining derived requirements as the progress on the knowledge of the interface develops.

When a part of the ICD content is linked to a requirement, the requirement Id must be captured in the ICD.

![Figure 2: SADT diagram of the Interface definition process.](image)

8. ROLES

The interface management involves several roles at different levels. The responsibility for the definition of the process is assigned to the Systems Engineer. The technical content of the ICDs is the responsibility of the working groups. The following table lists the different responsibilities and deliverables for the stakeholders involved in the interface definition.
<table>
<thead>
<tr>
<th>Name/Title</th>
<th>Responsibility</th>
<th>Deliverables</th>
</tr>
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<tbody>
<tr>
<td>CEO/DG</td>
<td>- Is responsible for solving disputes for ICD at levels 1.</td>
<td></td>
</tr>
<tr>
<td>Chairman of the CCB of the programme</td>
<td>- Is responsible for facilitating resolution of disputes for ICD at levels 1.</td>
<td></td>
</tr>
<tr>
<td>Project Manager for an ESS system</td>
<td>- Is responsible for solving disputes for ICD at level 2 and below.</td>
<td></td>
</tr>
<tr>
<td>Systems Engineering Division/Systems Engineering Manager</td>
<td>- Defines the processes and templates,</td>
<td>- First ICD version (functional flows)</td>
</tr>
<tr>
<td></td>
<td>- Orchestrates the process,</td>
<td>- This management plan</td>
</tr>
<tr>
<td></td>
<td>- Initiates ICD for levels 1.</td>
<td>- ICD templates</td>
</tr>
<tr>
<td></td>
<td>- Record derived requirements from the ICDs at level 1.</td>
<td></td>
</tr>
<tr>
<td>Systems Engineer for a Part</td>
<td>- Relays the process for level 2 and below.</td>
<td>- First ICD version (functional flows)</td>
</tr>
<tr>
<td></td>
<td>- Initiates ICD for level 2 and below.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Record derived requirements from the ICD at level 2 and below.</td>
<td></td>
</tr>
<tr>
<td>Project planner</td>
<td>Contributes to the milestones definition for each ICD.</td>
<td>- First ICD version (milestones)</td>
</tr>
<tr>
<td>ICD editor</td>
<td>- Edit with the support of the SE and the project planner of the area of interest the content of the ICD,</td>
<td>- ICD versions for each milestone.</td>
</tr>
<tr>
<td></td>
<td>- Is the secretary of the working group meetings,</td>
<td></td>
</tr>
<tr>
<td>Working group system representative</td>
<td>Contributes to ICD sections with technical contents.</td>
<td>- Technical reports</td>
</tr>
</tbody>
</table>
Product Lead Engineer or system owner

- Is the editor for the A2x ICDs
- ICD versions for each milestone
- CAD models

Integration and Design Support Division Head

- Is responsible for the ESS Plant layout Management.
- EPL versions

9. INTERFACE SPECIFICATION TRACEABILITY

The working groups for the interface specification will benefit from the progress of the ESS baseline development. Thus, it is important to make sure that the different versions of the baseline include the interface specifications. Trace-links between an ICD and the concerned systems (PBS elements) will enable the integration of their content in the analyses that will support the configuration management. Trace-links between an A2Be ICD and related A2x ICDs shall be maintained.