IDM UID
JQLRRK

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EXTERNAL REFERENCE / VERSION

CODAC Architecture / Design Description Document

01_Diagnostics Plant I&C Design Process (SRS and SDS) with link to templates and examples

This document provides an overview on how design diagnostics plant I&C and how to produce design deliverables for diagnostics plant I&C

Approval Process			
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01_Diagnostics Plant I&C Design Process (SRS and SDS) with link to templates and examples (JQLRRK)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	Approved	02 Sep 2013	
v1.1	Approved	24 Sep 2013	Operation and Maintenance Manual referance added
v1.2	Approved	14 Nov 2013	Added functional breakdown template link
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DIAGNOSTICS PLANT I&C DESIGN PROCESS

Plant I&C Design Guideline

Abstract

This document provides an overview on how design diagnostics plant I&C and how to produce design deliverables for diagnostics plant I&C

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List of Abbreviations

Table 1: List of Abbreviations

Abbreviation	Expanded Form
CBS	Control Breakdown Structure
CDR	Conceptual Design Review
CODAC	Control Data Access And Communication
CSS	Control System Studio
DA	Domestic Agency
FAT	Factory Acceptance Testing
FDR	Final Design Review
I&C	Instrumentation and Control
IDM	ITER Document Management
IO	ITER Organization
IO-CT	ITER Organization Central Team
MRR	Manufacture Readiness Review
ITER	International Thermonuclear Experimental Reactor
OMM	Operations and Maintenance Manual
PBS	Plant Breakdown Structure
PCDH	Plant Control Design Handbook
PDR	Preliminary Design Review
PS	Plant System
RD	Reference Document
RO	Responsible Officer
SAT	Site Acceptance Testing
SMS	System Manufacturing Specification
SDS	System Design Specification
SRS	System Requirement Specification
STP	System Test Plan
STR	System Test Report

1 Introduction

This document complies with the PCDH by focusing on deliverables and workflows applicable to plant system I&C design.

***Note:** This document is a live document. IDM link and design information will be updated as available*

This Document describes Plant System (PS) I&C deliverables for all Life cycle Phases.

The Life cycle Phases for PS I&C include:

a) Requirement Specification (Capture all Plant I&C requirements)
b) PS I&C Design
c) PS I&C Manufacture Initialization
d) PS I&C Manufacture
e) PS I&C Factory Acceptance Testing (FAT) and Integration with Mini-CODAC
f) PS I&C Installation
g) PS I&C Site Acceptance Testing (SAT)
h) PS I&C Commissioning

1.1 Life cycle Phases

The Plant Control Design Handbook (PCDH) specifies a set of inputs and deliverables for each Phase in PS I&C Life cycle. Guidelines and Rules are available for designers and developers of PS I&C for each Phase of the Life cycle. Each of the Life cycle Phases represents a major milestone in the development and deployment of the in-kind contributions by the Domestic Agencies (DA).

As a part of PS procurement, the process of PS I&C shall comply with the general scheme and procedures used for the ITER project.

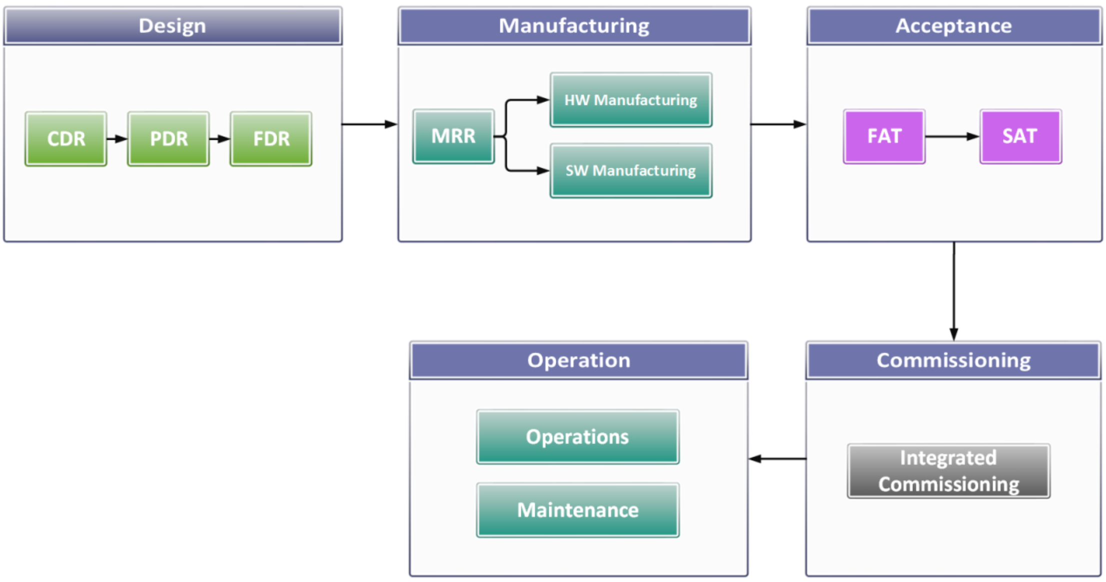

Figure 1: Plant I&C Life cycle Phases

- Design Phase - PS I&C design is followed by a project review. The Design Phase has three steps namely, conceptual, preliminary and detailed design. In this Design Phase System requirement specification and system design specification documents is required to be produced.

- Manufacturing Phase – Manufacturing Phase consist of manufacturing readiness review and I&C component manufacturing (Hardware and Software). In this Phase system, manufacturing document is required to be produced.
- Acceptance Phase – Acceptance Phase consist of factory acceptance test, installation on site and site acceptance test. Individual test of I&C component is required to perform during FAT.
- Integrated Commissioning - In integrated commissioning, SAT includes integration of PS I&C subsystems and acceptance tests of the whole PS I&C, if applicable.
- Operation and Maintenance Phases - These two Phases are merged together as they are closely linked, but are considered separately in this document.
- Decommissioning Phase - completes the PS I&C Life cycle, but is outside the scope of PCDH.

Each Phase or step is characterized by its outputs, which are the deliverables at completion of the Phase or the step. The outputs from one Phase or step are used as inputs to the next Phase or step together with PS I&C requirements and guidelines, as provided in this document and other ITER handbooks.

1.2 System Engineering

Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. An engineering management focuses on how to design and manage complex systems over their Life cycles.

Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical requirements of all customers with the goal of providing a quality product that meets the user needs.

Normally the ITER diagnostics system will follow V model for System Engineering. The typical V model is shown in Figure 2: V Model for System Engineering.

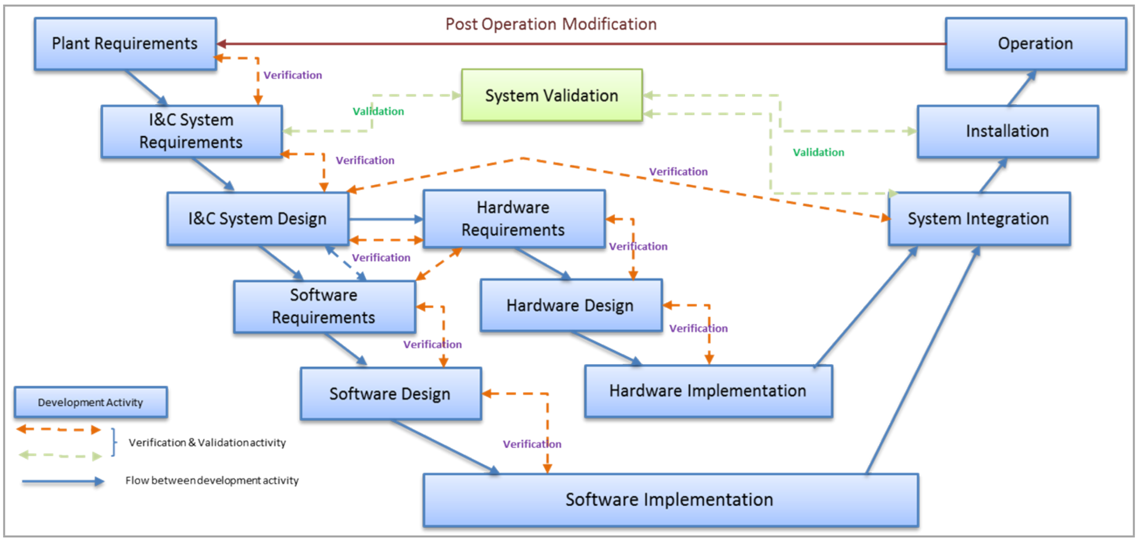

Figure 2: V Model for System Engineering

The plant system I&C deliverables for all Diagnostics Plant I&C are described in detail in the "Plant System I&C Deliverables for Diagnostics " [RD1] which is integral part of this Annex B. The mandatory I&C design rules and the physics data structure are also described in this document.

The "Methodology for Plant I&C Specifications" [RD3] describes scope and workflow for I&C design data.
On general demand and in collaboration with Domestic Agencies the IO has developed templates and examples for the Diagnostics I&C documentation, covering the relevant deliverables:

Deliverables for Diagnostics Plant I&C:

- System Requirement Specification (SRS)
- System Design Specification (SDS)
- System Manufacturing Specification (SMS)
- System Test Plan and Reports (STP) for FAT and SAT
- System Operation and Maintenance Manual (OMM)
- Diagrams and descriptions in DB based repository (Enterprise Architect) (With exception of cubicle configuration and cabling diagrams where other tools are used (SEE electrical expert or AutoCAD))

Table 2: Plant I&C Deliverables and Life cycle Phases

Document	Documentation	Plant I&C Life cycle Phases					
		PDR	FDR	MRR	FAT	SAT	Operation
SRS	Use Cases, Requirements, High Level operation principles, Level 2 functional Analysis	✓	✓				
SDS	Detailed Operation Procedures, Detailed functional Analysis, Detailed Plant I&C Architecture, State Machine	✓	✓				
EA Project		✓	✓	✓	✓	✓	✓
Interface Sheet	Interface sheet and Interface Data Sheet	✓	✓	✓	✓	✓	✓
STP					✓	✓	
	Test Scenarios	✓	✓		✓	✓	
	Test Set-up	✓	✓		✓	✓	
	Test Procedures				✓	✓	
	Evaluation Criteria				✓	✓	
STR					✓	✓	
SMS				✓			
OMM						✓	✓

1.3 Reference Documents [RD]

Table 3 lists the Reference documents.

Table 3: Reference Documentation

Ref. No	Reference Name	Reference Link
[RD1]	I&C deliverables for Diagnostics Annex B	ITER_D_3MQKJS
[RD2]	Plant Control Design Handbook (PCDH)	ITER_D_27LH2V
[RD3]	Methodology for Plant System I&C specifications	ITER_D_353AZY
[RD4]	Functional Breakdown for Diagnostics Plant I&C	ITER_D_LAJF9S
[RD5]	Example Template - Functional Breakdown Structure for Diagnostics	ITER_D_KE685T
[RD6]	Diagnostics System Requirement Specification (SRS) Template	ITER_D_NBNJRD
[RD7]	Diagnostics System Design Specification (SDS) Template	ITER_D_NE7NHC
[RD8]	ITER Numbering System for Parts/Components	ITER_D_28QDBS
[RD9]	I&C signal and variable naming convention	ITER_D_2UT8SH
[RD10]	TTT Code for ITER Component	ITER_D_43WDW9 TTT_PSP
[RD11]	Requirement Management Guideline	ITER_D_UNL5VW
[RD12]	State Machine Design Guideline	ITER_D_UKHVM5
[RD13]	Enterprise Architect User Manual	ITER_D_Q77FFP
[RD14]	Enterprise Architect Specification and Roadmap	ITER_D_X7VA3C

2 Overview

2.1 Diagnostics Plant I&C Design Workflow

The workflow for plant I&C design documentation with its PCDH deliverables is shown in Figure 3: Plant I&C Design Flow, Figure 4: Plant I&C Design Process and Figure 5: Plant I&C Design Documentation Workflow.

1. Plant I&C designer starts with the requirements (use cases and I&C requirements) of the relevant diagnostics system.
2. This is followed by description of the operational procedure of the relevant diagnostics.
3. Functional breakdown to level 2 for conceptual design and level 6 for detailed design. The functions have to support all operational requirements with process variables and their attributes being defined for individual functions in the detailed design.
4. Hardware architecture is developed, such that all of the functions can be implemented. The allocation of functions to hardware will be also documented.
5. A state machine for automation will be defined, the cubicle layout with all cabling documentation developed and the interface sheets produced.

All of these deliverables are documented in the design documents.

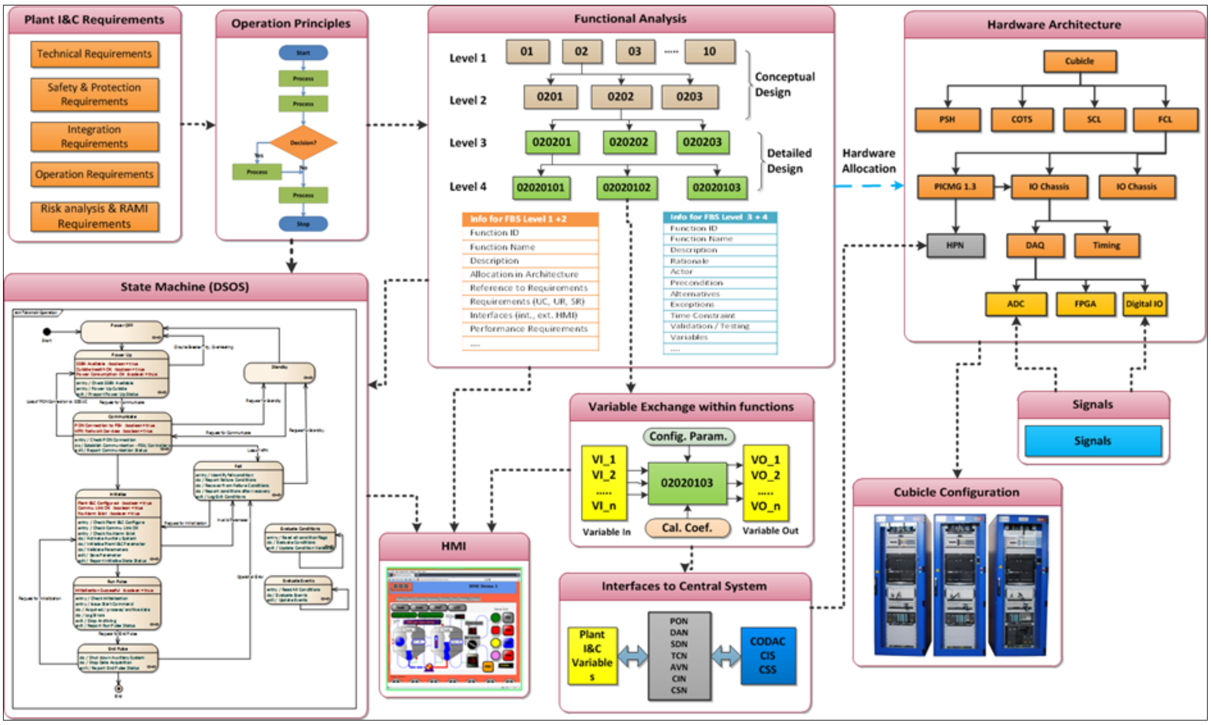

Figure 3: Plant I&C Design Flow

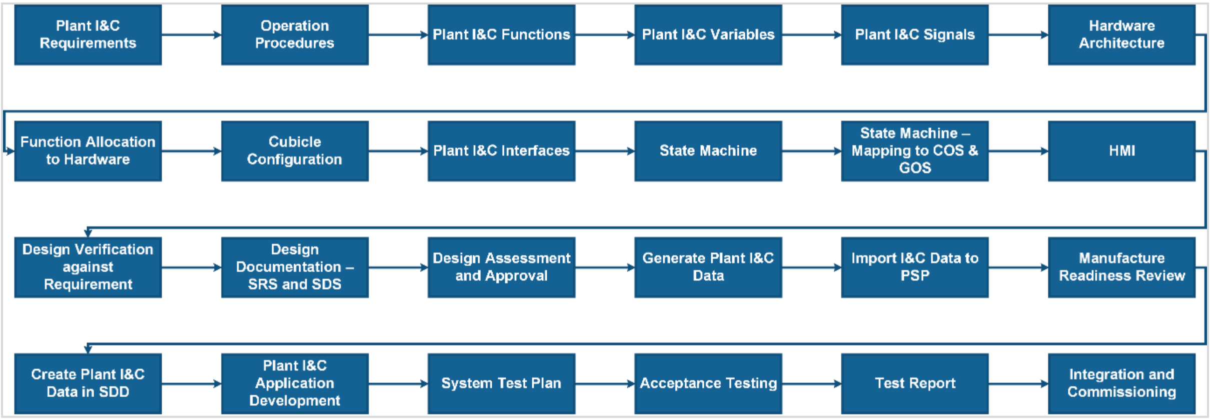

Figure 4: Plant I&C Design Process

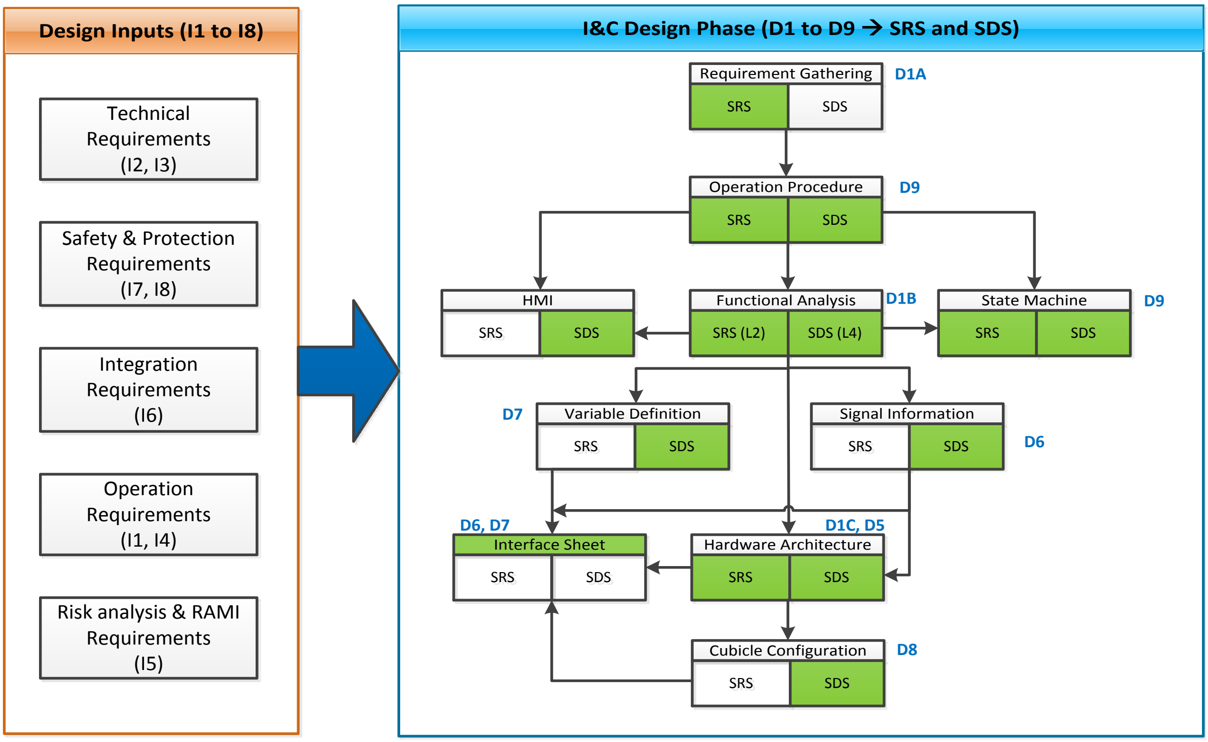

Figure 5: Plant I&C Design Documentation Workflow

3 Plant I&C Design Topics

This section will describe the different Plant I&C design topics that are required to be covered in the SRS and SDS document.

3.1 Plant I&C Use cases and Requirements

ITER plant I&C Requirements can be divided into 5 categories

1. Use Cases (for whole diagnostics)
2. Functional Requirements (Conventional Plant I&C)
3. Non-functional Requirements (Conventional Plant I&C
4. Interlock Requirements (Interlock Plant I&C)
5. Safety Requirement (Safety Plant I&C)

The following table shows the example for Plant I&C requirements

Table 4: Plant I&C Requirements Guideline and Example

Document Name	IDM Link
Diagnostics Plant I&C Requirement Management Guideline	ITER_D_UNL5VW
Diagnostics Plant I&C Requirement Example (Excel)	ITER_D_QCBZX8
Example of Use cases	ITER_D_X7VG4C SharePoint
Diagnostics Plant I&C SharePoint Page	SharePoint

The following Figure 6 shows the requirement breakdown ITER diagnostics plant I&C system

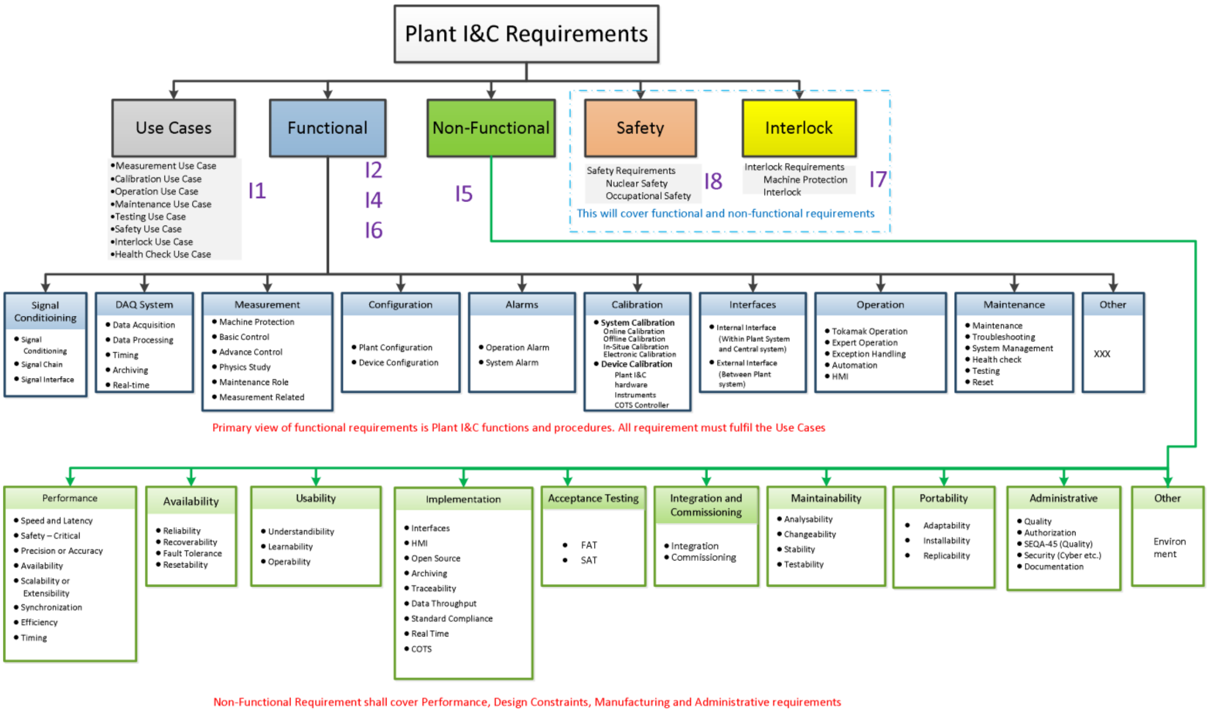

Figure 6: Requirement Breakdown

See Requirement Management guideline document [RD11] to understand more on Plant I&C requirements

3.1.1 Use Cases

Use cases documentation is a powerful, user-centric method for the system requirements specification process. Use case typically starts from identifying key stakeholder roles (actors) interacting with the system, and their goals or objectives the system must fulfil (an outside perspective).

Use case must cover following information:

- Use Case – Title
- Use Case – ID
- Use Case – Scope / description
- Use Case – Stakeholders
- Use Case – Actors
- Use Case – Priority / Criticality
- Use Case – Frequency of Use
- Use Case – Preconditions
- Use Case – Post Conditions (Minimal Guarantee, Success Guarantee)
- **Use Case – Basic / Normal Flow (Important in use case)**
- Use Case – Limitations
- Use Case – Exceptions
- Use Case - Assumptions
- Use Case – Business Rules

Plant system shall cover following use cases (minimum) on following topics

- Measurement

- Calibration
- Operation
- Acceptance Testing
- Health Check
- Maintenance
- Configuration
- Interlock (if applicable)
- Safety (if applicable)

Also see Table 4 for Guideline and examples

3.1.2 Functional Requirements

Functional requirement defines a function of a system or its component. Functional requirements may be calculations, data manipulation and processing and other specific functionality that define what a system is supposed to accomplish.

A typical functional requirement will contain a unique name and number, a brief summary, and a rationale. This information is used to help the reader understand why the requirement is needed, and to track the requirement through the development of the system

See Figure 6 for functional requirement breakdown.

Also see Table 4 for Guideline and examples

3.1.3 Non-Functional Requirements

Non-functional requirements are requirements that specifies criteria that can be used to judge the operation of a system, rather than a specific behaviors or functions

Functional requirements are supported by non-functional requirements, which impose constraints on the design or implementation (such as performance requirements, security, or reliability).

See Figure 6 for non-functional requirement breakdown

Also see Table 4 for Guideline and examples

3.1.4 Interlock Requirements

Interlock requirements consist of functional interlock and non-function interlock requirement. Interlock requirements are mainly identified for Machine protection and Interlock.

See Table 4 for Guideline and examples

3.1.5 Safety Requirements

Safety requirements consist of functional safety and non-functional safety requirements. Safety requirements consist of occupational safety and nuclear safety

See Table 4 for Guideline and examples

3.2 Plant I&C Operation Procedures

Plant I&C Operation procedures shall cover

- Tokamak Operation
- Expert Operation
- FAT Procedure
- SAT Procedure
- Integration and Commissioning Procedure
- Maintenance Procedure
- Plant Protection Procedure
- Occupational Safety Procedure

Each operation procedure typically covers:

1. Tokamak operation
    1.1. Configure I&C (default)
    1.2. Initialize for intended purpose
    1.3. Run (plant I&C)
    1.4. Stop (plant I&C)
2. Expert operation by diagnostics TRO
    2.1. Calibration
    2.2. Exception detection
    2.3. Exception handling
    2.4. Fault recovery
    2.5. Health check
3. FAT testing procedures
    3.1. Install system from source code
    3.2. Validate FAT test pre-requisites
    3.3. Verify essential components or devices (timing, DAQ, and so on.)
    3.4. Determine integrity of signal chain
    3.5. Characterize components in signal chain
    3.6. Validate functions against requirements
    3.7. Evaluate procedures
4. SAT Testing procedures
    4.1. Install system from source code
    4.2. Validate SAT test pre-requisites
    4.3. Check communication
    4.4. Operate through Mini-SUP
    4.5. Configure using Mini-Config (Pulse schedule)
5. Integrated Commissioning procedures
    5.1. Connect plant I&C to central CODAC
    5.2. Operate through Supervision (SUP)
    5.3. Configure using pulse - schedule
6. Maintenance procedures
    6.1. Power up
    6.2. Hardware maintenance
    6.3. Software upgrade
7. System conditioning procedures
    7.1. Burn-in system
    7.2. Condition high power system
    7.3. Condition high voltage system
8. Plant protection procedures
    8.1. Graceful shut down
    8.2. Protect from overload
    8.3. Protect from excessive temperature

9. Occupational safety procedures
    9.1. Laser safety operation
    9.2. High voltage safety operation

3.3 Function Breakdown for Diagnostics Plant I&C

Diagnostics functional breakdown will be used to identify each Plant I&C function. The functional breakdown is generated using several functional group types. These group types are identified based on device functionality, usage function, system management, operation procedure, Plant I&C interface, Data acquisition, Data Processing COTS and so on. Functional breakdown is performed up to level 6. In that Level 1 and Level 2 are the conceptual design while Level 3 to 6 is detailed design

3.3.1 Rational for Functional Breakdown

1. Breakdown based on compromise of different functional requirements in plant I&C Life cycle
    - Specification
    - Design
    - Implementation
    - Acceptance Testing
    - Commissioning
    - Operation
    - Maintenance
    - Protection and Safety
2. Functional views sorted in about 22 groups
    - Around 13 generic main groups
        i. Plant operators global
        ii. Operation procedure
        iii. Instrumentation (Measurement) and Control
        iv. (System) Management
        v. (System) Usage
        vi. (Subsystem) Usage
        vii. (Device) Usage
        viii. (Component) Usage
        ix. Commercial control
        x. Plant system (other PBS)
        xi. Signal conditioning
        xii. Data acquisition or data processing
        xiii. Interface
    - Around 9 function specific groups
        i. Measurement and Control related
        ii. Interface related
        iii. Signal conditioning specific (filtering)
        iv. Data acquisition specific (data types)
        v. Data processing specific (math functions)
        vi. COTS specific

vii. System management specific
viii. Machine protection specific
ix. Occupational safety specific

3. Functional breakdown to level 2 describes conceptual design in hierarchical structure
   - Attempt of generic breakdown since all diagnostics serve same goal and common concept
   - Level 1 takes into account
     i. Global and local functionality
     ii. Signal chain from producer (sensor or actuator) to consumers (applications)
     iii. Standard (see signal chain) and commercial controllers
     iv. Conventional, protection, safety
     v. Usage (operation) and (system) management
   - Level 2 take into account
     i. Functional view groups matching level 1 requirements
     ii. Instrumentation and Control view
4. Functional breakdown to level 4 (and 5) describes detailed design in non-hierarchical structure but operationally preferred structure
   - Generic usage and management functional view groups
   - Specific usage and management functional view groups
   - Preferred structure can be re-arranged if beneficial for plant I&C development and deployment.

Detailed description of Functional Breakdown is available in ITER_D_LAJF9S

3.3.2 Level 1 and Level 2 Functions

Diagnostics plant I&C functions are categorized in ten level 1 functions (FBS 1). The functions have been optimized to cover the needs for all life-cycle phases of the plant I&C.

Table 5: Level 1 Functions

Level 1 Function (FBS 1)	Description
Global	If the diagnostics plant system has interface with other plant system (including other diagnostics system), then the functions related to other plant system must be defined under Global Function
Signal Conditioning	Functions related to signal conditioning are needed to define under signal conditioning functions. Signal conditioning functions covers signal interface, sensors pre-amplifiers, filters and processing, attenuation, isolation, multiplexing, digital signal conditioning, actuators drive and so on.
Data Acquisition	Functions related to data acquisition like A/D conversion, raw data, timing, D/A conversion, frame grabbing, pre-processing are needed to define under this function.
Data Processing	Functions related to data processing like measurement, control, feedback, calibration, analysis, filters are needed to define under this function.
System Management	Functions related to Plant I&C system management like Cubicle management, Controller (Fast and Slow) management, I/O Boards and so on are needed to

Level 1 Function (FBS 1)	Description
	define under this function.
Operation	Functions related to operation like plant automation, conditions, events, plant configurations and are needed to define under this function.
Machine Protection	Functions related to machine protection are needed to define under this function.
Occupational Safety	Functions related to occupational safety are needed to define under this function.
Commercial Measurement and Control	Functions related to COTS devices are needed to define under this function.
Interfaces	Functions related to interfaces like DAN, SDN, PON, TCS and so on are defined under this function.

The following figure shows the level 1 and Level 2 breakdown for diagnostics functions analysis.

Refer Appendix I Appendix I for diagnostics I&C functional breakdown structure

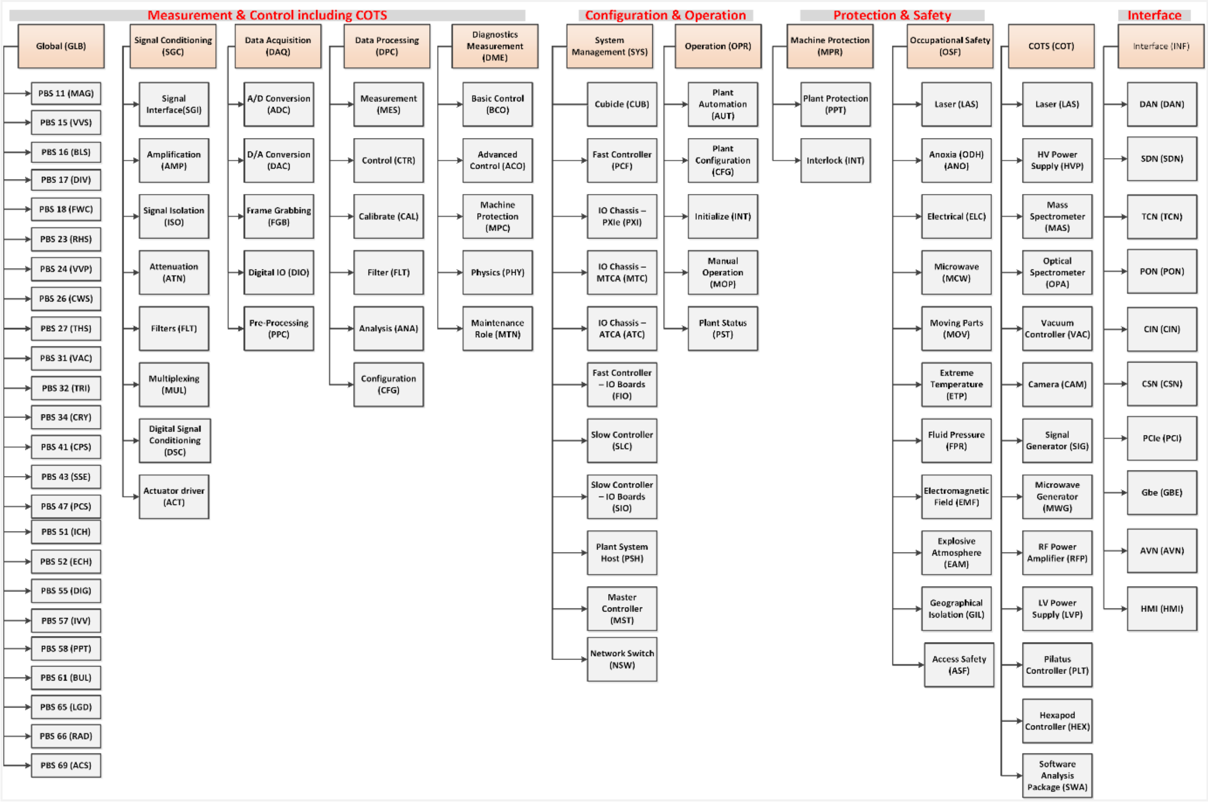

Figure 7: Level 2 Functional Breakdown for Diagnostics Plant I&C

Table 6: Example - Functional Breakdown for Diagnostics Plant I&C

Template Name	IDM Link
Functional Breakdown for Diagnostics Plant I&C – Template	KE685T

3.3.3 Variable Naming for Diagnostics Plant I&C

A naming convention has been set up and is already applicable for ITER components. The plant I&C systems include components, which must be named accordingly.

In addition to this, since signals and variables of the plant I&C system cannot be identified by the component naming convention alone (a controller, sensor and actuator may be connected to several signals) the need arises for a convention tailored to signal and variables specificities.

The variable name format is **Control Function Identifier: Variable Identifier.**
The variable identifier is a free string of 24 characters maximum VV…VV, provided the full name including the function identifier is unique within the whole ITER plant.

Only alphanumeric characters should be used, with "-" (hyphen) permitted as a separator. Any alphabetic character used in names shall be in upper case.

Therefore, the variable name format is:

FFFF-……FFFF: VV….VV

Since the FBS has a limited number of levels (typically 6) and we are constructing the FBS from functional groups, we cannot always cover all functional information in them. Additional information will the attribute groups which may include functional groups if needed.

Finally variable can be only distinguished by different attributes; this information needs to get into the name (very cryptic like 1 (or 2) characters per attribute group). Refer ITER_D_X7R88V for variable attributes.

Therefore, the naming concept of diagnostics plant I&C variable is

CBS1-CBS2-CBS3-FBS1-FBS2:FBS3-FBS4-FBS5-FBS6-A1A2A3A4A5

Where A1..A5 are attributes 1 to 5

Detailed description of Variable naming is available in ITER_D_X7R88V

3.3.3.1 Variable Naming Example

Table 7: Variable Naming Example

Function and Variable Identifier	Name / Code	Description
CBS 1	D1	Diagnostics Control Group
CBS 2	H1	55.A0 Magnetics Diagnostics System
CBS 3	A000	55.A0.00 Magnetics System, Electronics & Software
FBS 1	DAQ	Data Acquisition
FBS 2	ADC	A to D Conversion
FBS 3	RW	Raw Data
FBS 4	PL	Proportional
FBS 5	A3	Coil A3
FBS 6	3001	Coil number 3001
A1	MR	Measurement – Raw Data (Variable Type)
A2	RE	Read (Action)
A3	PO	PON (Interface)
A4	CU	Current (Quantity)
A5	RA	Raw Analog Value

From the example of above table, the Variable name is

D1-H1-A000-DAQ-ADC:RW-PL-A3-3001-MRREPOCURA

3.4 State Machine (Automation)

As mentioned in PCDH Each of Plant Systems has to manage the operation state of its system(s) with or without subsystem(s) in order to obtain the operation status and or progress.

The PSOS are reflecting the specific state of operation of a plant system. PSOS are implemented by state machines.

Typical states for state machine are shown as per the following Figure 8.

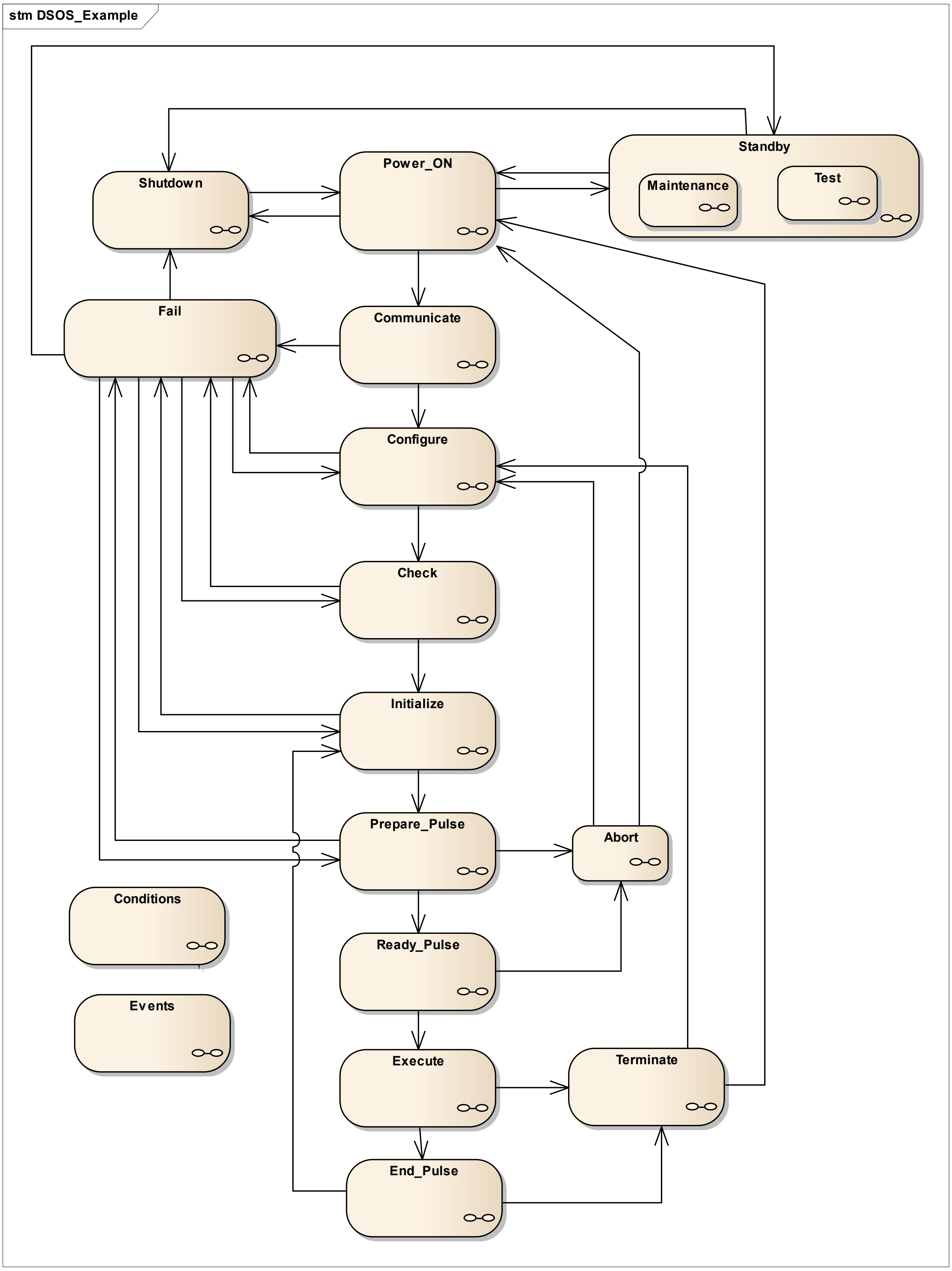

Figure 8: Typical States for State Machine

For More information please refer - State Machine Design Guideline [RD12] (ITER_D_UKHVM5)

3.5 Plant I&C Hardware Architecture

Each plant system has to design I&C Architecture.

Below figure shows the standard I&C Architecture for ITER Plant system

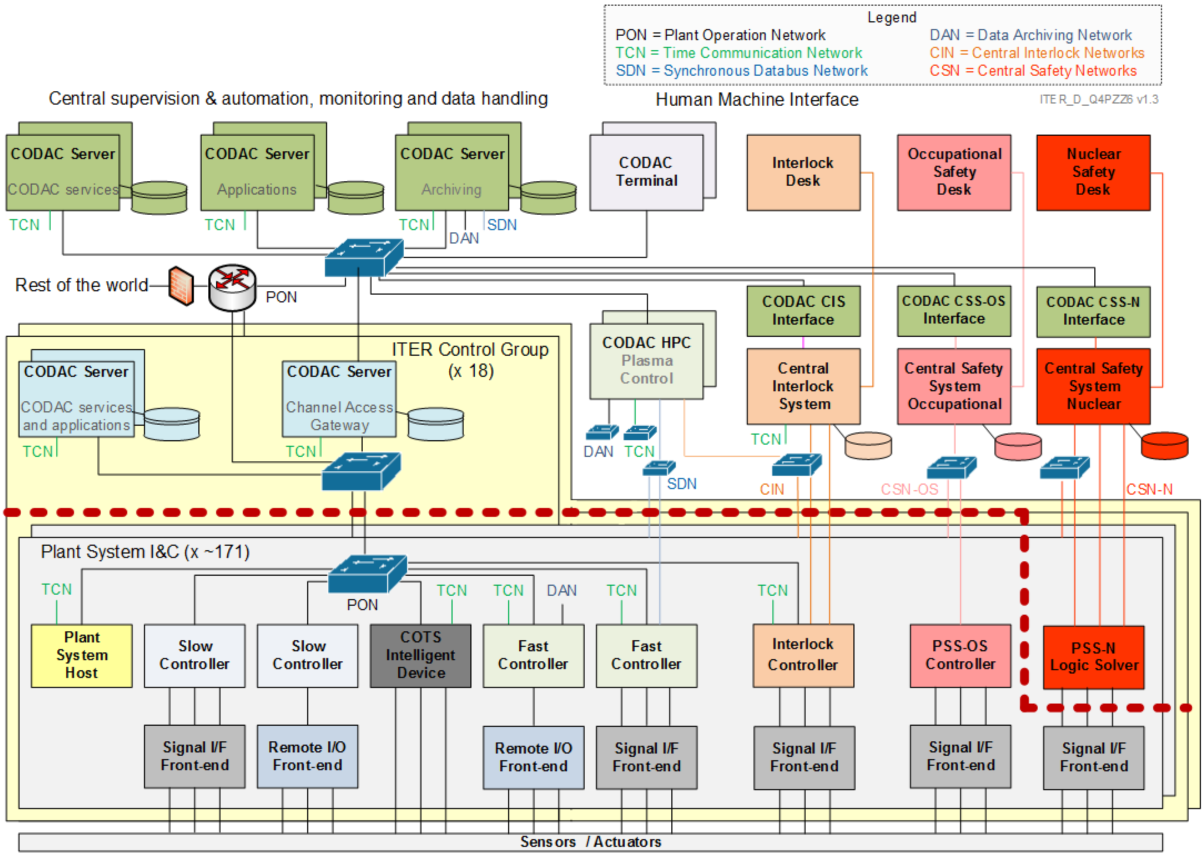

Figure 9: ITER I&C Architecture

Plant I&C Architecture Includes

1. I&C Hardware Architecture
2. Cubicle Configuration (Includes layout, Wiring Diagram etc.)
3. Plant I&C Signals
4. COTS Interface (if applicable)
5. Bill of Material

3.5.1 Example of I&C Architecture Diagrams

Below diagram shows the example of Hardware and Software Architecture developed in Enterprise Architect Project

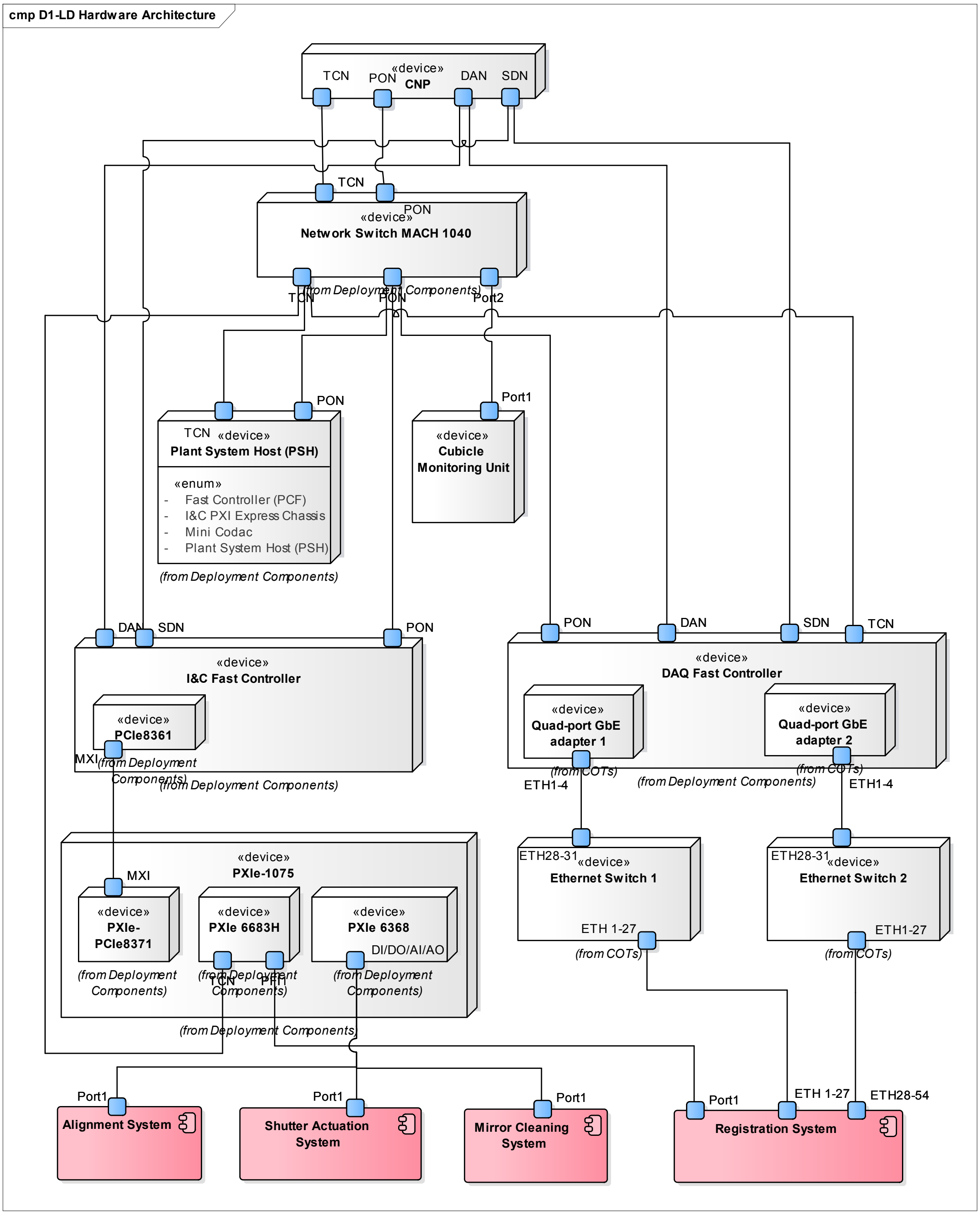

Figure 10: Hardware Architecture Example

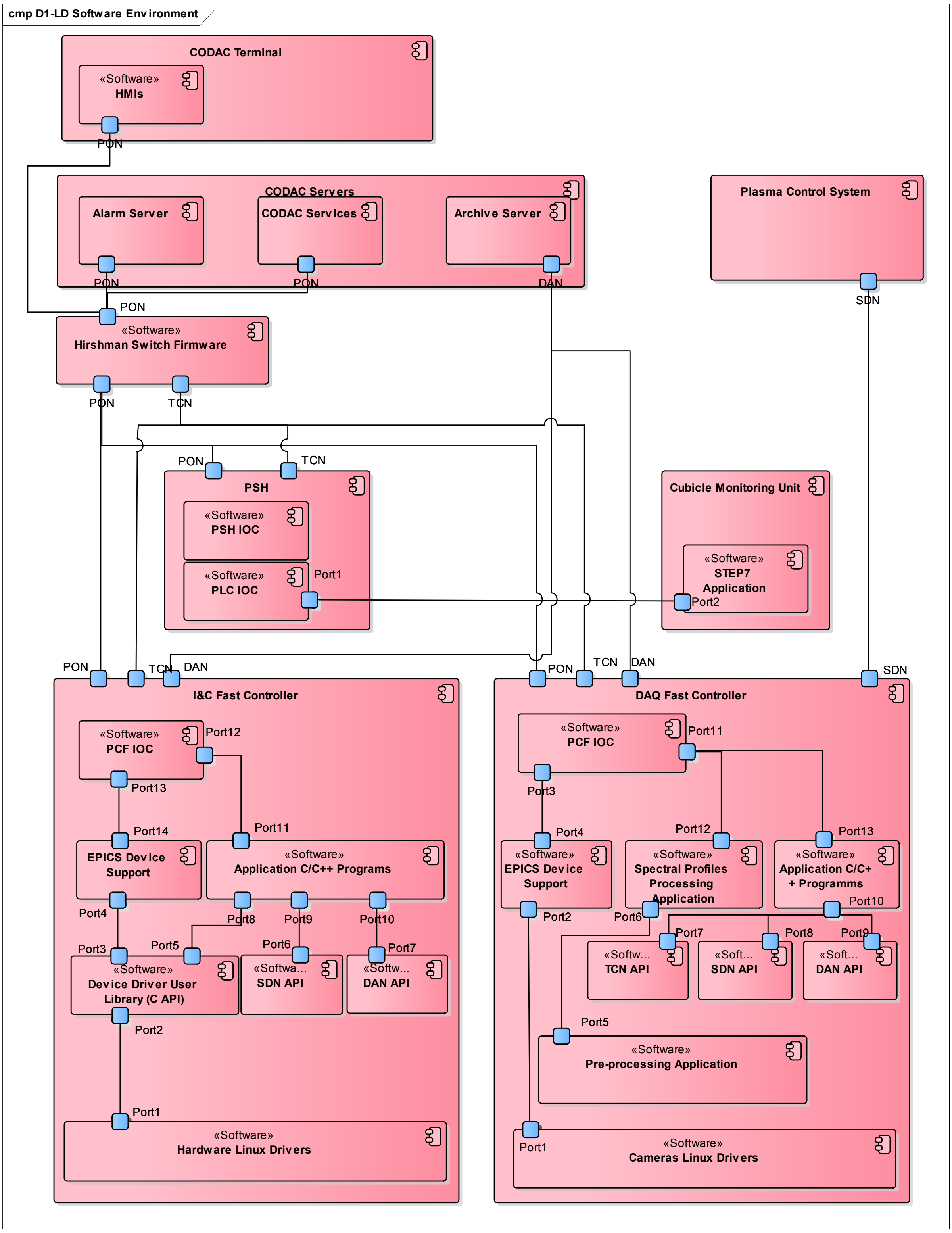

Figure 11: Software Architecture

3.6 Interface Sheet

The interface sheet consist of two parts:

1. Interface Sheet

2. Interface Data Sheet

The interface sheet describes physical and functional interfaces in different plant I&C Life cycle Phases. Interface data sheet consists of all data (Variables, Signals controllers, cubicle and so on.) which will be used within Plant I&C and interface to central Plant I&C

Table 8: Example of Interface Sheet

Interface Sheet Name	Example IDM Link (IS)	Example IDM Link (IDS)
Interface Sheet to PBS 45	RRG97C (Example)	TBD
Interface Sheet to PBS 46	TBD	TBD
Interface Sheet to PBS 48	P8V83R	PNZDBF

4 Enterprise Architect for Diagnostics Plant I&C Design

Enterprise Architect enters full Life cycle modelling for Software and Systems Engineering. With built-in requirements management capabilities, Enterprise Architect helps to trace high-level specifications to analysis, design, implementation, test and maintenance models using UML, SysML, and other open standards. Using high quality and built-in reporting and documentation, it can deliver a truly shared vision easily and accurately.

Use of EA in plant I&C design and implementation process shown Figure 12

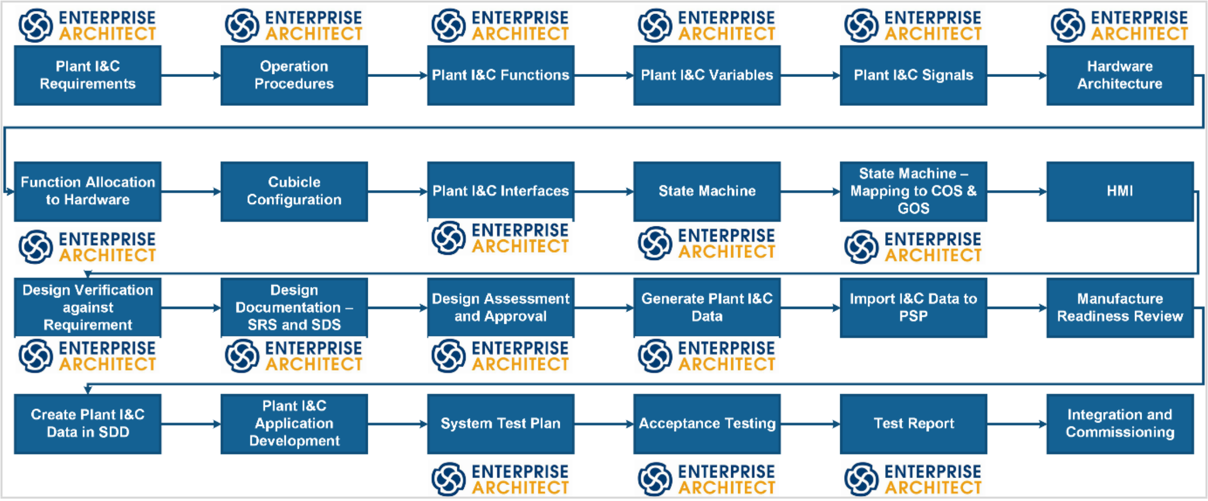

Figure 12: EA for Plant I&C Design and Implementation

Enterprise Architect Add-in and road-map is available in IDM [ITER_D_X7VA3C]

4.1 EA Features for Plant I&C Design

The EA Features are follows:

- Visual Modelling Platform
    - Comprehensive UML analysis and design tool.
    - Rich modelling for software and systems.
    - Full traceability from requirements to deployment.
    - Code engineering in over 10 languages
- High Value, End-To-End Modelling
- Enters full life cycle modelling for: Software and Systems Engineering
- Built-in requirements management capabilities,
- Traceability of high-level specifications to analysis, design, implementation, test and maintenance models using UML, SysML, and other open standards.
- Enterprise Architect is a multi-user, graphical tool to build robust and maintainable systems.
- Loads extremely large models in seconds.
- Easily accommodates large teams sharing the same view of the enterprise.
- Tightly integrated version control capabilities
- Complete traceability from requirements, analysis and design models, through to implementation and deployment.

- Effective verification, validation and immediate impact analysis are possible across the entire life cycle, using such capabilities as Enterprise Architect's Relationship Matrix and Hierarchy View
- Use of impact analysis to trace proposed changes to original requirements
- Built-in requirements management features can be used to:
    - Define an organized, hierarchical requirements model
    - Trace the implementation of system requirements to model elements
    - Search and report on requirement
    - Perform impact analysis of proposed changes to requirements
- Enters powerful document generation and reporting tools with a full template editor.
- Generate detailed reports with the needed information in the desired format
- Automatically produce HTML versions of the model for easy distribution over the Internet or intranet
- Supports generation and reverse engineering of source code for many popular languages, including: ActionScript , Ada , C and C++ , C# , Java , Delphi , Verilog , PHP, VHDL , Python , System C , VB.Net , Visual Basic and more
- Script repetitive tasks, such as property update common to all model elements
- Generate code from a state machine or diagram
- Produce custom reports

4.2 EA Add-ins for Plant I&C Design

EA Enters Add-in feature. Using this feature, it can be easily communicating to external world / application. Add-in will help designer to simplify design process. Also Add-in will help designer to reduce documentation effort

Figure 13: EA Add-ins for Plant I&C design shows the EA add-ins used in the plant I&C design

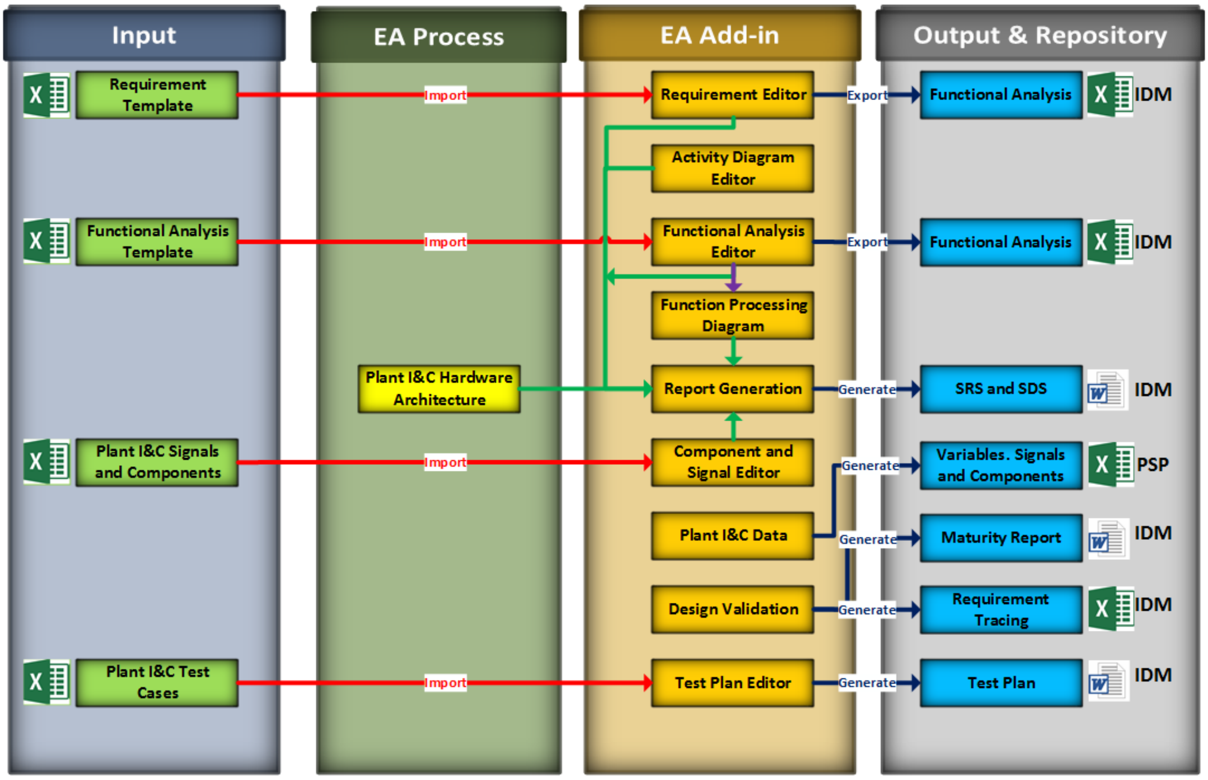

Figure 13: EA Add-ins for Plant I&C design

For more information, refer EA User Manual [ITER_D_Q77FFP]

5 Diagnostics Design documents

In scope of the ITER design reviews, a set of documentation are specified in the PCDH to be delivered an reviewed. These documentation target the functional and physical interfaces with central I&C systems. These are listed below:

- D1 Plant system I&C architecture.
- D5 Plant system controller(s) performance and configuration requirements.
- D6 List of inputs and outputs (I/O) of the I&C controllers.
- D7 List of data at Central I&C functional interface.
- D8 Configuration of I&C cubicles.
- D9 Specifications of plant system operating state machines.

These deliverables are assumed to be reviewed in the Design Reviews of the PA or Plant Systems

Two design documents System requirement specification (SRS) and System Design Specification (SDS) are need to produce for Diagnostics Plant I&C Design. PCDH design deliverables are mapped to SRS and SDS, the same is described below

D1 Plant system I&C architecture

D1A: Functional Analysis to Level 2 **(Consolidation of I1 - I8 →SRS, SDS, EA)**

D1B: Functional Analysis to level 4 **(Detailed design, → SRS, SDS, EA)**

D1C: Physical Architecture **(Conventional, Safety, Interlock → SRS, SDS, EA)**

D5 Plant system controller(s) configuration **(Slow, Fast, COTS → SDS, PSP, EA)**

D6 List of input and output signals of the I&C controllers **(SDS, PSP, EA)**

D7 List of variables of CODAC functional interface **(PSP, EA → IS)**

D8 Configuration of I&C cubicles **(SDS)**

D9 Specifications of plant system operating state machines **(SDS, EA)**

Plant I&C Design deliverables mapping to SRS and SDS

Table 9: I&C Design Deliverables Mapping to SRS and SDS Document

Deliverables	PCDH Description	SRS Chapter	SDS Chapter
D1A	D1A target is to collect all inputs from I1 to I8 in a single document. In addition, the CBS down to level 2 is specified. The plant system equipment interfaced to the plant system I&C are listed but not in details.	Chapter 1 to Chapter 7	Chapter 1, Chapter 2, Chapter 3
D1B	D1B provides the functional specifications for the control functions. Several D1B documents may be required for covering a plant system depending on its D1 complexity. Conventional, Interlock and Safety controls are addressed.	Chapter 5 (Level 2 Functional Breakdown)	Chapter 4 (Detailed Functional breakdown Level 4 or 5)
D1C	D1C is the compilation of the D1Bs for	Chapter 6	Chapter 6

Deliverables	PCDH Description	SRS Chapter	SDS Chapter
	determining the physical architecture and functional Specification of the plant system I&C. The control functions are allocated to controllers depending on performance, suitability and location. The controller network interfaces are identified, functionally and physically specified. This deliverable is required for specifying the interface of the plant system I&C with the central I&C systems.	(High Level)	Detailed
D5	D5 provides the specifications of I&C controller type (slow/fast), (conventional/interlock, Safety) and network configuration. The details of these specifications will be determined by the I&C supplier.		Chapter 6
D6	D6 provides the list of signals connected to the plant system I&C including name, type, sampling rate, allocation to I&C cubicles and location. This deliverable is required for specifying the configuration of the controllers and the data interfaced to central I&C systems.		Chapter 6 (Section 6.2), EA, PSP
D7	D7 is the list of data at central I&C interface.		Chapter 4, PSP, EA, Interface Sheet
D8	D8 provides the hardware configuration of I&C cubicles and cubicle internal wiring. D8 includes for each I&C cubicle: the enclosure type and the HVAC configuration if some interface (for example, chilled water is required). This deliverable is required for specifying the configuration of the cubicle interface with the buildings, power supply and cable trays.		Chapter 8
D9	D9 provides the state machines specifications for the Plant System Operating States (PSOS) and the mapping with the Common Operating States (COS) This deliverable is required for preparing the integrated operation of the plant system.		Chapter 5

***Note:** All Deliverables (D1 – D9) are mapped to Diagnostics SRS Template (NBNJRD) and Diagnostics SDS Template (NE7NHC)*

Over the Plant I&C Lifecycle Phases 5 main documents need to Produce.

- System Requirement Specification (SRS)
- System Design Specification (SDS)
- System Manufacturing Specification (SMS)
- System Test Plan/Reports (STP)
- System Operation and Maintenance Manual (OMM)

- Diagrams and descriptions in DB based repository (Enterprise Architect)

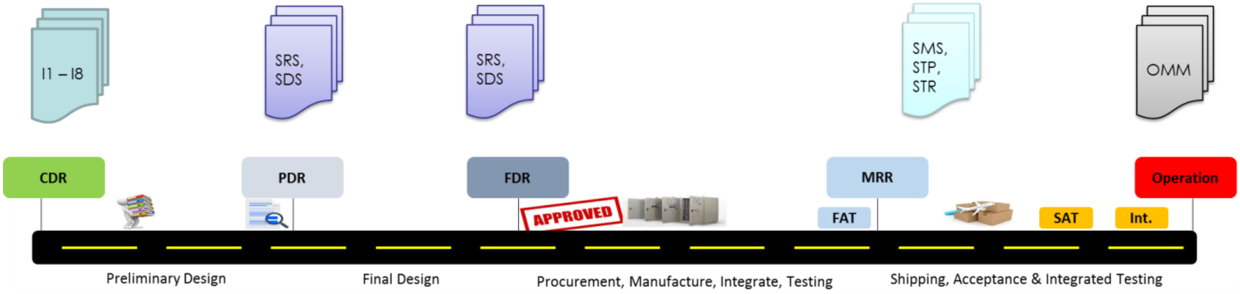

Figure 14: Documentation over I&C Lifecycle Phases

Development Process of SMS, STP, STR and OMM will be described separately

6 Plant I&C Design Maturity Assessment for Design Reviews

The maturity assessment for design is performed both quantitatively and qualitatively. Quality assessment is performed through sample checks (min 10%). Use cases and requirements are considered as input to design and hence do not contribute to design maturity.

The table below shows the weightage for each design topic in the assessment. The weights are given, mostly based on the effort required for each design topic.

Table 10. Weightage for various design elements

Design Topics (items in blue are typically required at FDR stage)		Weightage
Procedures	Procedures	13
	Exceptional Handling Procedures	2
	Procedure to Function Mapping	5
Functions	Functions (including timing constraints)	12
	Pass Fail Criteria	3
	Function Processing Diagram/ Input variables	5
	Algorithms	2.5
	Function to Requirement Mapping	2.5
Variables	Variables (including smart conditions)	10
	Variables Attributes (including Hardware Allocation)	5
Hardware Architecture	Signals and Components	5
	Hardware Architecture	5
	Obsolescence management plan	2
	Cubicle Configuration	7
	BOM	4
	ITER Part Number	2
State Machine	States	7
	Allocation of procedures to states	3
HMI	HMI	3
Test scenarios	Test scenarios	2

Composite (quantitative + qualitative) maturity for each design element, is calculated by multiplying the quantitative and qualitative maturities.

Eg. Suppose for the design element 'Procedures' the quantitative maturity is 60% and qualitative maturity is 70%. Then the composite maturity of this design element would be (.7)(.6) = 42%*

Since the weightage of this design element is 13, the overall contribution to the design maturity is 42 percent of 13 i.e. 5.46%

By performing the above exercise for all the design elements, we obtain the overall design maturity or FDR design maturity.

For PDR, the expectation is that the PDR design maturity is **well above** 70%.

Please note PDR design maturity = 2*FDR design maturity

How the quantitative and qualitative assessment for each design element is carried out, is explained here onwards. **An item to be considered for quantitative maturity should have a minimum quality.**

6.1 Procedures

Quantitative –The I&C designer needs to estimate the number of procedures required at different levels for his system. For reference, the designer may look at the typical number of procedures (at different levels for different category of systems) configured in the maturity assessment add-in.

Quantitative maturity is calculated based on the number of procedures that have been documented in the design, taking the I&C designer's estimate as the base.

Quantitative maturity = [(Completion % for Level 1 procedures) + (Completion % for Level 2 procedures) + (Completion % for Level 3 procedures)]/3

The procedure breakdown may be more than Level 3, depending on the plant I&C design.

Minimum quality for quantitative maturity - Title and description of procedure is clearly understandable

Qualitative – The following criteria is used for qualitative maturity-

- Procedure Description Tables complete
- Procedures can be mapped to functions through steps
- Procedures support all use cases in detail
- Min 10% sample check method for estimating quality

6.2 Exceptional Handling Procedures

Quantitative – to be defined

Qualitative – to be defined

6.3 Procedure to Function Mapping

Quantitative – to be defined

Qualitative – to be defined

6.4 Functions (including timing constraints)

Quantitative – The I&C designer needs to estimate the number of functions required at different levels for his system. For reference, the designer may look at the typical number of functions (at different levels for different category of systems) configured in the maturity assessment add-in.

Quantitative maturity is calculated based on the number of functions that have been documented in the design, taking the I&C designer's estimate as the base.

Quantitative maturity = [(Completion % for Level 1 functions) + (Completion % for Level 2 functions) + (Completion % for Level 3 functions) + (Completion % for Level 4 functions) + (Completion % for Level 5 functions)]/5

Minimum quality for quantitative maturity - Name and description of function clearly understandable

Note- **Since the functions at the lowest level lead to variables, the design effort for functions and variables is highly correlated.**

Qualitative – The following criteria is used for qualitative maturity-

- Functions designed to support all procedures
- Functions supporting requirements
- Description of the functions should be sufficiently detailed so that the developer can implement the function
- Timing constraints for the lowest level functions are defined
- Min 10% sample check method for estimating quality

6.5 Pass Fail Criteria

Quantitative – The same value as calculated for functions (assuming for all defined functions, pass fail criteria has been defined). Min 10% sample check method for estimating quantity to be used otherwise.

Qualitative – Pass/fail criteria with respect to requirements defined correctly. Min 10% sample check method for estimating quality.

6.6 Function Processing Diagram/ Input variables

Quantitative – The same value as calculated for functions (assuming for all defined functions, input variables have been defined). Min 10% sample check method for estimating quantity to be used otherwise.

Qualitative – For checking the quality of the input variables, a signal chain (typically for single channel) is constructed using the functional analysis. Gaps (if any) are identified and clarified with the I&C designer. The quality is estimated by expert judgement from the exercise above.

6.7 Algorithms

Quantitative – The same value as calculated for functions (assuming for all defined functions, algorithms have been defined). Min 10% sample check method for estimating quantity to be used otherwise.

Qualitative – to be defined

6.8 Function to Requirement Mapping

Quantitative – The same value as calculated for functions (assuming for all defined functions, function to requirement has been done). Min 10% sample check method for estimating quantity to be used otherwise.

Qualitative – The mapping is correct. All requirements are met.

6.9 Variables (including smart conditions)

Quantitative – The I&C designer needs to estimate the number of variables of different types (like alarm, configuration, condition, control..) required for his system. For reference, the designer may look at the typical number of variables (of different types for different category of systems) configured in the maturity assessment add-in.

Quantitative maturity is calculated based on the number of variables that have been documented in the design, taking the I&C designer's estimate as the base.

Quantitative maturity = [(Completion % for Level 6 functions) + (Completion % for Type 1 variables) + (Completion % for Type 2 variables) + …. + (Completion % for Type n variables)]/(n+1)

Minimum quality for quantitative maturity - Description of variable is clear understandable

Qualitative – The following criteria is used for qualitative maturity-

- Smart conditions for automation have been defined
- All types of variables have been defined (also covered through quantitative assessment)

6.10 Variables Attributes (including Hardware Allocation)

Quantitative – The same value as calculated for variables (assuming for all defined variables, attributes have been defined). Min 10% sample check method for estimating quantity to be used otherwise.

Qualitative – Verify correctness of the following attributes

- Attribute 1
- Attribute 2
- Attribute 3
- Attribute 4
- Attribute 5
- Archive
- Upper Limit
- Lower Limit
- Alarm
- Alarm Type
- Alarm Priority
- Alarm Low Limit
- Alarm Low Low Limit
- Alarm High Limit
- Alarm High High Limit
- Available on HMI
- Interface
- Data Type
- Data Kind
- Category
- Unit

- Hardware Allocation
- Signal Name

Min 10% sample check method used.

6.11 Signals and Components

Quantitative – Estimated after reviewing design, since quantification is difficult.

Qualitative – The following criteria is used for qualitative maturity-

- Description of signals and components understandable
- Naming as per the rules
- Allocation of signal to I/O input can be identified
- All attributes for signals and components defined.

6.12 Hardware Architecture

Quantitative – Estimated after reviewing design, since quantification is difficult. Some pointers below-

- All hardware components (cubicles, chassis, boards, devices …) covered
- COTS interface defined

Qualitative – The following criteria is used for qualitative maturity-

- Components correctly named in architecture (cubicle, chassis, boards)
- Controllers specification available (standard and custom)
- Communication links (internal, external) understandable
- COTS interface compliant (see black box checklist)

6.13 Obsolescence management plan

Quantitative – to be defined

Qualitative – as per PCDH

6.14 Cubicle Configuration

Quantitative – Items to be considered for quantitative maturity

- Cubicle Layout
- Cubicle internal wiring diagram

Qualitative – The following criteria is used for qualitative maturity-

- Network interfaces compatible with interface sheet
- Component naming correct

6.15 BOM

Quantitative – BOM should be available.

Qualitative – BOM should be correct.

6.16 ITER Part Number

Quantitative – BOM should have ITER part numbers for all items.

Qualitative – ITER part numbers should be correct.

6.17 States

Quantitative – The I&C designer needs to estimate the number of states (simple and complex), flows, conditions, events and transitions required for his system. For reference, the designer may look at the typical number configured in the maturity assessment add-in.

Quantitative maturity is calculated based on the number of items that have been documented in the design, taking the I&C designer's estimate as the base.

Quantitative maturity = [(Completion % for complex states) + (Completion % for flows) + (Completion % for simple states) + (Completion % for conditions) + (Completion % for events) + (Completion % for transitions)]/6

Qualitative – The following criteria is used for qualitative maturity-

- Title and description of states understandable
- State machine supports all procedures
- Allocation of procedures to states can be identified
- System identification well supported and transitions clear

6.18 Allocation of procedures to states

Quantitative – Allocation should be complete.

Qualitative – Allocation should be correct.

6.19 HMI

Quantitative – to be defined

Qualitative – to be defined

6.20 Test scenarios

Quantitative – to be defined

Qualitative – to be defined

7 Checklist for Design Review (PDR and FDR)

This section provides overview on checklist for Plant I&C design documents and design topics.

7.1 Checklist for Documentation

Table 11: Checklist for Documentation

Documentation	PDR Maturity Level	FDR Maturity Level
System Requirement Specification (SRS)	Refined	Final
System Design Specification (SDS)	Refined	Final
EA Project	Refined	Final
Interface Sheet	Preliminary	Refined
Interface Data Sheet	Preliminary	Refined

7.2 Checklist for Requirements

Table 12: Checklist for Requirements

Requirement Type	PDR Maturity Level	FDR Maturity Level
Use Cases	Refined	Final
Functional Requirements	Refined	Final
Non-Functional Requirements	Refined	Final
Interlock Requirements	Refined	Final
Safety Requirements	Refined	Final

7.3 Checklist for Operation Procedures

Table 13: Checklist for Operation Procedures

Operation Procedure	PDR Maturity Level	FDR Maturity Level
Tokamak Operation	Refined	Final
Expert Operation	Refined	Final
Interlock and Safety Procedure	Refined	Final
Exception and Error Handling	Refined	Final
FAT Procedure	Preliminary	Refined
SAT Procedure	Preliminary	Refined
Maintenance Procedure	Preliminary	Refined
Integration and Commissioning Procedure	Preliminary	Refined

Functions to Procedure Mapping	Refined	Final
HMI Screens	Preliminary	Refined

7.4 Checklist for Functions

Table 14: Checklist for Functions

Functions	PDR Maturity Level	FDR Maturity Level
Functional Analysis Coverage	80%	100%
Pass or Fail criteria for Each Function	Preliminary	Final
Requirements mapping to functions	Preliminary	Final
Function description (Includes Role and Usage, Timing Constraints, Algorithms and Equations and so on)	Preliminary	Final
Function Processing diagram (Includes input or output variables, configuration and so on)	Preliminary	Final
Hardware Allocation	Preliminary	Final

7.5 Checklist for Variables

Table 15: Checklist for Variables

Variable Description	PDR Maturity Level	FDR Maturity Level
All Variable Types (Control, Measurement , Configuration, Timing, Alarm, State, Condition, Event, Calibration, System Management, Health Summary, Performance, Error, Metadata)	Preliminary	Refined
Variable Attributes (Naming, Implementation (SDD, Data Type, HMI, Archive, Alarm and so on) Units, Signal Mapping, Limits and so on)	Preliminary	Refined
Device Variables	Preliminary	Refined
SYSM Variables	Preliminary	Refined
NDS Variables	Preliminary	Refined
Service Variables	Preliminary	Refined

7.6 Checklist for Hardware Architecture

Table 16: Checklist for Hardware Architecture

Hardware Architecture Description	PDR Maturity Level	FDR Maturity Level
Plant I&C Hardware from catalog	Refined	Final
Deviation policy for I&C hardware outside catalog	Preliminary	Final
Hardware Specification	Refined	Final
Network Configuration	Refined	Final
COTS Interfaces and compliance evaluation	Refined	Final
Obsolescence management plan	Refined	Final

7.7 Checklist for Bill of Material

Table 17: Checklist for BOM

BOM description	PDR Maturity Level	FDR Maturity Level
BOM for LCC with ITER Part number and order information	Refined	Final
BOM for SCC with ITER Part number and order information	Refined	Final
List of Spares	Refined	Final

7.8 Checklist for signals

Table 18: Checklist for Signals

Signal description	PDR Maturity Level	FDR Maturity Level
Detailed Signal List	Refined	Final

7.9 Checklist for Cubicle Configuration

Table 19:Checklist for Cubicle Confogurations

Cubicle description	PDR Maturity Level	FDR Maturity Level
All cubicles layout and location information	Refined	Final
Internal wiring diagram	Refined	Final
Connection to external signal and interfaces	Refined	Final
Heat-Load or Power calculations	Refined	Final

7.10 Checklist for State Machine

Table 20: Checklist for State Machine

State Machine Description	PDR Maturity Level	FDR Maturity Level
Automation States	Refined	Final
Conditions and Events	Refined	Final
Transitions	Refined	Final
Allocate procedures to States	Refined	Final
COS-PSOS Mapping	Refined	Final
GOS-PSOS Mapping	Refined	Final

7.11 Checklist for Test Scenarios

Table 21: Checklist for Test Scenarios

Description	PDR Maturity Level	FDR Maturity Level
Test Scenarios	Preliminary	Refined
Acceptance Criteria	Preliminary	Refined

Appendix I Level 1 and Level 2 Function Code

Table 22: FBS 1 (Level 1) CODES

FBS 1 (Level 1 Function)	FBS 1 Code	Description
Global	GLB	If the diagnostics plant system has interface with other plant system (including other diagnostics system), then the functions related to other plant system must be defined under Global Function.
Signal Conditioning	SGC	Functions related to signal conditioning are needed to define under signal conditioning functions. Signal conditioning functions covers signal interface, sensors pre-amplifiers, filters and processing, attenuation, isolation, multiplexing, digital signal conditioning, actuators drive and so on.
Data Acquisition	DAQ	Functions related to data acquisition like A/D conversion, raw data, timing, D/A conversion, frame grabbing, pre-processing are needed to define under this function.
Data Processing	DPC	Functions related to data processing like measurement, control, feedback, calibration, analysis, filters are needed to define under this function.
System Management	SYS	Functions related to Plant I&C system management like Cubicle management, Controller (Fast and Slow) management, I/O Boards and so on are needed to define under this function.
Operations	OPR	Functions related to operation like plant automation, conditions, events, plant configurations and so on are needed to define under this function.
Machine Protection	MPR	Functions related to machine protection are needed to define under this function.
Occupational Safety	OSF	Functions related to occupational safety are needed to define under this function.
Commercial Off the shelf (COTS)	COT	Functions related to COTS devices are needed to define under this function.
Interfaces	INF	Functions related to interfaces like DAN, SDN, PON, TCS and so on are defined under this function.

Level 2 Breakdown – Global Function

Table 23: FBS 2 Codes – Global Function

FBS 2 (Level 2 Function)	FBS 2 Code	Description
PBS 11 Magnets	MAG	Describes the functional interface with PBS 11 which covers measurement, control configuration and so on.
PBS 15 Vacuum Vessel and IV Coils	VVS	Describes the functional interface with PBS 15 which covers measurement, control configuration and so on.
PBS 16 Blanket System	BLS	Describes the functional interface with PBS 16 which covers measurement, control configuration and so on.
PBS 17 Divertor	DIV	Describes the functional interface with PBS 17 which covers measurement, control configuration and so on.
PBS 18 Fueling and Wall Conditioning	FWC	Describes the functional interface with PBS 18 which covers measurement, control configuration and so on.
PBS 23 Remote Handling Systems	RHS	Describes the functional interface with PBS 23 which covers measurement, control configuration and so on.
PBS 24 VVPSS and Cryostat	VVP	Describes the functional interface with PBS 24 which covers measurement, control configuration and so on.
PBS 26 Cooling Water System	CWS	Describes the functional interface with PBS 26 which covers measurement, control configuration and so on.
PBS 27 Thermal Shield	THS	Describes the functional interface with PBS 27 which covers measurement, control configuration and so on.
PBS 31 Vacuum	VAC	Describes the functional interface with PBS 31 which covers measurement, control configuration and so on.
PBS 32 Tritium Plant	TRI	Describes the functional interface with PBS 32 which covers measurement, control configuration and so on.
PBS 34 Cryoplant and Cryodistribution	CRY	Describes the functional interface with PBS 34 which covers measurement, control configuration and so on.
PBS 41 Coil Power Supply and Distribution	CPS	Describes the functional interface with PBS 41 which covers measurement, control configuration and so on.
PBS 43 Steady State Electrical Power Supply Networks	SSE	Describes the functional interface with PBS 43 which covers measurement, control configuration and so

FBS 2 (Level 2 Function)	FBS 2 Code	Description
		on.
PBS 47 Plasma Control System	PCS	Describes the functional interface with PBS 47 which covers measurement, control configuration and so on.
PBS 51 ICH	ICH	Describes the functional interface with PBS 51 which covers measurement, control configuration and so on.
PBS 52 ECH	ECH	Describes the functional interface with PBS 52 which covers measurement, control configuration and so on.
PBS 55 Diagnostics	DIG	Describes the functional interface with PBS 55 which covers measurement, control configuration and so on.
PBS 57 IVVS	IVV	Describes the functional interface with PBS 57 which covers measurement, control configuration and so on.
PBS 58 PPTF	PPT	Describes the functional interface with PBS 58 which covers measurement, control configuration and so on.
PBS 61 Building	BUL	Describes the functional interface with PBS 61 which covers measurement, control configuration and so on.
PBS 65 Liquid and Gas Distribution	LGD	Describes the functional interface with PBS 65 which covers measurement, control configuration and so on.
PBS 66 Radwaste	RAD	Describes the functional interface with PBS 66 which covers measurement, control configuration and so on.
PBS 69 Access Control and Security	ACS	Describes the functional interface with PBS 69 which covers measurement, control configuration and so on.

Level 2 Breakdown – Signal Conditioning

Table 24: FBS 2 Codes – Signal Conditioning

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Signal Interface	SGI	This function describes the signal interface functions (Control, Configure monitor and so on) related to Plant I&C.
Amplification Drive	AMP	This function describes the functional view (Control, Configure monitor and so on) related to amplification / drive in Plant System I&C.

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Signal Isolation	ISO	This function describes the functional view (Control, Configure monitor and so on) related to Signal Isolation in Plant System I&C.
Attenuation	ATN	This function describes the functional view (Control, Configure monitor and so on) related to Attenuation in Plant System I&C.
Multiplexing	MUL	This function describes the functional view (Control, Configure monitor and so on) related to multiplexing in Plant System I&C.
Digital Signal Processing	DSP	This function describes the functional view (Control, Configure monitor and so on) related to Digital signal processing in Plant System I&C.
Actuators / Drive	ACT	This function describes the functional view (Control, Configure monitor and so on) related to Actuators / drive in Plant System I&C.
Filters	FLT	This function describes the functional view (Control, Configure monitor and so on) related to Analog filters in Plant System I&C.

Level 2 Breakdown – Data Acquisition

Table 25: FBS 2 Codes – Data Acquisition

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Analog to Digital Conversion	ADC	This function mainly covers the Data Acquisition (Raw data (Analog and Digitized), Timing (Clock and Triggers), Data Acquisition configuration and so on).
Digital to Analog Conversion	DAC	This function mainly covers the Data Acquisition (Analog Output, Timing, Data Acquisition Configuration and so on).
Frame Grabbing	FGB	This function mainly covers the Data Acquisition (Image Acquisition).
Digital (I/O)	DIO	This mainly covers the functions (control, monitor and so on) related to digital input and output.
Pre-Processing	PPC	This function covers the pre-processing functions which will be performed on raw data to be used for data processing.

Level 2 Breakdown – Data Processing

Table 26: FBS 2 Codes – Data Processing

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Measurement	MES	This covers the measurement functions related to diagnostics system. This will cover the diagnostics measurement as well as other measurements.
Control	CTR	This covers the control functions related to diagnostics system. For example, Control Shutter, Valve, PID control and so on.
Configuration	CFG	This covers the configuration function related to diagnostics measurement. For example, Algorithm configuration, reference values, and so on.
Alarm	ALM	This covers the alarm functions related to diagnostics measurement and Plant System I&C. Alarm function shall cover alarm configurations, set-points, errors warnings and so on.
Calibration	CAL	This covers the calibration function related to diagnostics measurement and Plant System I&C. Calibration functions shall covers obtain calibration, apply calibration, verification and so on.
Analysis	ANA	This function covers the analysis for the measurement.
Filter	FLT	This covers the filter function used for the data processing.
Statistics	STA	This covers the statistics for the data processing.

Level 2 Breakdown – System Management

Table 27: FBS 2 Codes – System Management

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Cubicle	CUB	This function describes the system management related to Plant I&C cubicles which also includes health management.
Fast Controller CPU	PCF	This function describes the system management related to Fast Controller CPU which also includes health management.
Fast Controller IO Chassis – PXIe	PXI	This function describes the system management related to Fast Controller PXIe IO Chassis which also includes health management.
Fast Controller IO Chassis – MTCA	MTC	This function describes the system management related to Fast Controller MTCA.4 IO Chassis which also includes health management.
Fast Controller IO Chassis – ATCA	ATC	This function describes the system management related to Fast Controller ATCA IO Chassis which also includes

FBS 2 (Level 2 Function)	FBS 2 Code	Description
		health management.
Fast Controller IO Boards	FIO	This function describes the system management related to Fast Controller IO Boards which also includes health management.
Slow Controller	SLC	This function describes the system management related to Slow Controller which also includes health management.
Slow Controller IO Boards	SIO	This function describes the system management related to Slow Controller IO Boards which also includes health management.
Plant System Host	PSH	This function describes the system management related to Plant System Host which also includes health management.
Network Switch	NSW	This function describes the system management related to Network Switch which also includes health management.
Master Controller	MST	This function describes the system management related to Master Controller which also includes health management.

Level 2 Breakdown – Operations

Table 28: FBS 2 Codes – Operations

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Automation	AUT	This describes the automation function used across the plant I&C lifecycle phases. This includes plant system conditions, events transitions and so on.
Initialization	INT	This describes the initialization (intended purpose) related to Plant System I&C. This shall cover all plant I&C lifecycle phases.
Configuration	CFG	This describes the configuration functions related to plasma operations, expert operation and so on.
Plant Status	PST	This function provides plat system status (States).
Manual Operation	MOP	This function covers any manual operation in Plant I&C, for example, Manual response /comment capture, Manual On/Off and so on.

Level 2 Breakdown – Machine Protection

Table 29: FBS 2 Codes – Machine Protection

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Plant Protection	PPT	This describes the functions related to Plant Protection.
Interlock	INT	This describes the functions related to Interlock.

Level 2 Breakdown – Occupational Safety

Table 30: FBS 2 Codes – Occupational Safety

FBS 2 (Level 2 Function)	FBS 2 Code	Description
Anoxia (ODH)	ANO	This describes the occupation safety functions related to anoxia.
Electrical	ELC	This describes the occupational safety functions related to Electrical Hazard.
Laser	LAS	This describes the occupational safety functions related to LASER, which includes Laser Operations, Protection, Configuration and so on.
Microwave	MCW	This describes the occupational safety functions related to Microwave.
Moving Parts	MOV	This describes the occupational safety functions related to Heavy Moving Parts.
Extreme Temperature	ETP	This describes the occupational safety functions related to Extreme Temperature.
Fluid Pressure	FPR	This describes the occupational safety functions related to Fluid Pressure.
Electromagnetic field	EMF	This describes the occupational safety functions related to Electromagnetic Field.
Explosive atmosphere	EAM	This describes the occupational safety functions related to Explosive Atmosphere.
Geographical Isolation	GIL	This describes the occupational safety functions related to Geographical Isolation.
Access Safety	ACC	This describes the occupational safety functions related to Access Safety.

Level 2 Breakdown – COTS

Table 31: FBS 2 Codes - COTS

FBS 2 (Level 2 Function)	FBS 2 Code	Description
LASER Controller	LAS	This covers the interfacing functions between Plant I&C and COTS Device (Laser Controller). This covers

FBS 2 (Level 2 Function)	FBS 2 Code	Description
		Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
HV Power Supply	HVP	This covers the interfacing functions between Plant I&C and COTS Device (HV Power Supply). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
LV Power Supply	LVP	This covers the interfacing functions between Plant I&C and COTS Device (LV Power Supply). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Mass Spectrometer	MAS	This covers the interfacing functions between Plant I&C and COTS Device (Mass Spectrometer). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Optical Spectrometer	OPS	This covers the interfacing functions between Plant I&C and COTS Device (Optical Spectrometer). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Vacuum Controller	VAC	This covers the interfacing functions between Plant I&C and COTS Device (Vacuum Controller). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Camera	VAM	This covers the interfacing functions between Plant I&C and COTS Device (Cameras). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Signal Generator	SIG	This covers the interfacing functions between Plant I&C and COTS Device (Signal Generator). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Microwave generator	MWG	This covers the interfacing functions between Plant I&C and COTS Device (Microwave Generator). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
RF Power Amplifier	RFP	This covers the interfacing functions between Plant I&C and COTS Device (RF Power Amplifier). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Pre Amplifier	AMP	This covers the interfacing functions between Plant I&C and COTS Device (Pre Amplifier). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.
Pilatus Controller	PLT	This covers the interfacing functions between Plant I&C and COTS Device (Pilatus Controller). This covers Measurements, Control, Configurations, COTS Device

FBS 2 (Level 2 Function)	FBS 2 Code	Description
		Management, COTS Health Management and so on.
Hexapod Controller	HEX	This covers the interfacing functions between Plant I&C and COTS Device (Hexapod Controller). This covers Measurements, Control, Configurations, COTS Device Management, COTS Health Management and so on.

Level 2 Breakdown – Interfaces

Table 32: FBS 2 Codes - Interfaces

FBS 2 (Level 2 Function)	FBS 2 Code	Description
PON	PON	This covers the PON interface management which included Configuration, Performance, Health Management and so on.
DAN	DAN	This covers the DAN interface management which included Configuration, Performance, Health Management and so on.
SDN	SDN	This covers the SDN interface management which included Configuration, Performance, Health Management and so on.
AVN	AVN	This covers the AVN interface management which included Configuration, Performance, Health Management and so on.
TCN	TCN	This covers the TCN interface management which included Configuration, Performance, Health Management and so on.
PCIe	PCI	This covers the PCIe interface management which included Configuration, Performance, Health Management and so on.
HMI	HMI	This covers the HMI interface management which included Configuration, Performance, Health Management and so on.
CIN	CIN	This covers the CIN interface management which included Configuration, Performance, Health Management and so on.
CSN	CSN	This covers the CSN interface management which included Configuration, Performance, Health Management and so on.
GbE	GBE	This covers the GbE interface management which included Configuration, Performance, Health Management and so on.
USB	USB	This covers the USB interface management which included Configuration, Performance, Health Management and so on.

Appendix II System Requirement Specification

System Requirement Specification document will cover the PCDH deliverables D1A, D1B and D1C.

All ITER diagnostics procured according to functional specifications of the complete diagnostic system. Usually the requirements for plant I&C are not specified in sufficient details for the plant I&C designer. Therefore, the plant I&C system requirements has to be elaborated in more detail in the plant I&C system requirements specification (SRS) document

Following chapters are covered in the SRS document

- Chapter 1: Introduction
- Chapter 2: Overall Description
- Chapter 3: Plant I&C Overview
- Chapter 4: Plant I&C Requirement
- Chapter 5: Functional Specification (Requirement)
- Chapter 6: Plant I&C Architecture
- Chapter 7: Non Functional Requirement
- Chapter 8: Project Issue
- Chapter 9: Risk

Following link will provide SRS Example

Table 33: Example of SRS

Template Name	Template IDM Link	Example IDM Link
System Requirement Specification (SRS)	NBNJRD	V6N5LJ (Improved Version)

Note: *The SRS example is under development. It is not final version. There for example document may not reflect all chapters from SRS template*

Appendix III System Design Specification

While the System Requirements Specification provides a functional breakdown to level 2, the Design Specification elaborates on the details of the functions to at least level 4 (or more as necessary). System Design Specification document covers D1A, D1B, D1C, D5, D6, D7, D8 and D9 PCDH Deliverables.

Following chapters are covered in SDS document

- Chapter 1: Introduction
- Chapter 2: Design Strategies
- Chapter 3: Plant I&C Operation
- Chapter 4: Functional Design (Detailed)
- Chapter 5: Plant Automation (PSOS)
- Chapter 6: Plant I&C Hardware Architecture
- Chapter 7: Plant I&C Software overview
- Chapter 8: I&C Cubicle Configuration

Following link will provide SDS Example

Table 34: Example of SDS

Template Name	Template IDM Link	Example IDM Link
System Design Specification (SDS)	NE7NHC	V6N6SE (Improved Version)

Note: *The SDS example is under development. It is not final version. There for example document may not reflect all chapters from SDS template*

SDS - Chapter 1: Introduction

This chapter will provide an introduction of the SDS document. This chapter will cover following topics:

- **Purpose -** This section, describes purpose of the SDS document. It also covers the objectives and goal of the Plant I&C system in the plant I&C Design Phase.
- **Document Convention -** This section describes various convention that are used in SRS and SDS document.
- **Intended Audience -** This section describes intended audience and their role of SRS and SDS document
- **Project Scope -** This section describe project scope for example
    - Requirements verification (ensure all requirements are covered by the design)
    - Develop detailed operation procedure
    - Design Plant system Operating State Machine (PSOS)
    - Design detailed hardware architecture
    - Identify design functions that covers Plant system I&C requirements, operation procedure, PSOS
    - Breakdown I&C function from Level 1 to variable definition.
    - Allocate functions or variables to Hardware
    - Design cubicle configuration of diagnostics Plant I&C

- **Acronyms -** This section describe all acronyms used in the SRS document. For a complete list of ITER abbreviations see ITER Abbreviations ITER_D_2MU6W5
- **References -** This section mention all applicable and reference documents used to prepare SRS and SDS document

SDS - Chapter 2: Design Strategies

This chapter will describe Design Strategies of the project. This chapter will cover the following topics:

- **Description -** SDS document is complying with the ITER Plant Control Design Handbook (PCDH) including requirements for using components from the catalogue of standard ITER I&C hardware, either Micro Telecommunications Architecture (MTCA) or PXI Express (PXIe).
- **Maximum Reusability -** This section defines the maximum reusable components. The software modules pertaining to domain knowledge should be designed as libraries so that they can be reused in the future for similar projects.
    - Mathematics
    - Digital signal processing
    - Feedback control

  The design shall consider the reuse of software modules in similar projects. This will be largely handled by the use of CCS v5.x, which has standard functions to interface with standard ITER hardware modules for I&C. Software that can be reused includes:

    - EPICS device support for MTCA and PXIe hardware
    - Record support, including AI,AO,BI,BO,MBBI,MBBO records
    - Nominal Device Model implementation.
    - If any HMI is implemented for MFC that shall also be reused
- **Configurable Components -** This section defines configurable components of the Plant I&C System

SDS - Chapter 3: Plant I&C Operation

This chapter will describe in detail the Operation Procedure and will cover the following topics:

- Plant I&C Operation (Detailed)
- Factory Acceptance Procedure
- Site Acceptance Procedure
- Commissioning Procedure
- Maintenance Procedure
- Safety Procedure

The example of Plant system Operation and description is shown as per the following Figure 3-9

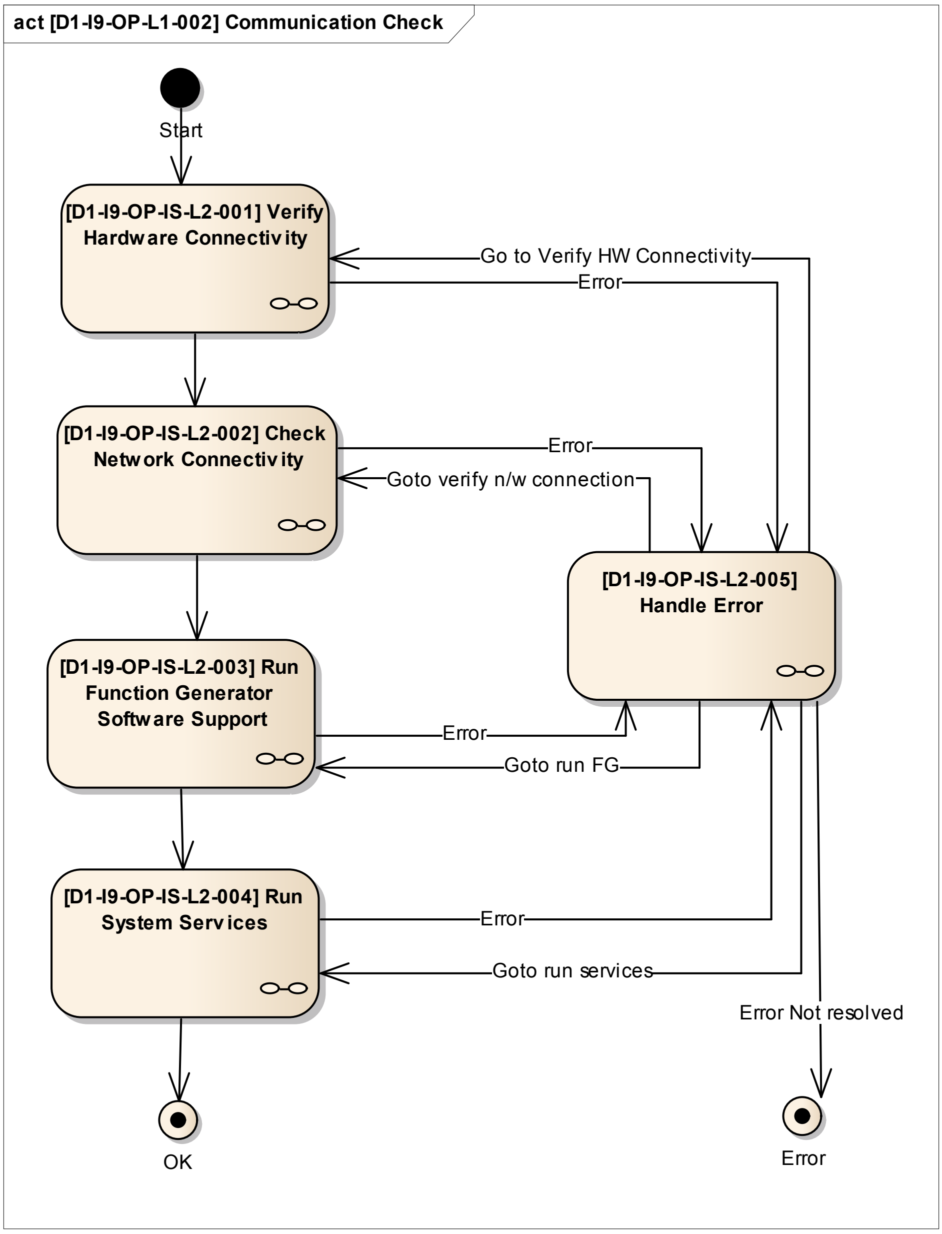

Figure 15: Example Operation Procedure

Example description of Operation procedure

Table 35: Example Description of Operation Procedure

Name	**Power ON**
Procedure ID	D2-UI-OP-L1-001
Description	This process will Power on all I&C devices, verify power consumption and cubicle health
Stakeholder	Diagnostician, I&C Engineer, PS Operator, Plant I&C Users
Actor	Diagnostician, I&C Engineer, PS Operator, Plant I&C Users
When Required	All Phases
Pre-Conditions	--
Allocation to Functions	Global, Data Acquisition, Data Processing, System Management, Operation, Interface
Frequency of Use	Beginning of Operation
Complexity	Simple

Name	Power ON
Notes	Power ON Plant I&C Devices Verify Power Conditions Report Power Status

The important level 1, level 2 and level 3 operation procedures are described in section **Error! Reference source not found.**

SDS - Chapter 4: Functional Design (Detailed)

This chapter cover detail Functional Design of Plant I&C. This will cover following high level function in detailed up to level 3, 4, 5.

- Global
- Signal Conditioning
- Data Acquisition
- Data Processing
- System Management
- Operation
- Machine Protection
- Occupational Safety
- Commercial measurement and control
- Interface

Each level 4 or 5 function will describe with variables associated with the functions, Timing Constraints, Algorithms, Variable attributes, and function validation.

The important level 3 and level 4 functions are described in **Error! Reference source not found.** The important variable types are describe in **Error! Reference source not found.**

Examples for the functional breakdown to levels 3 and 4 are shown in **Error! Reference source not found.** and **Error! Reference source not found.**

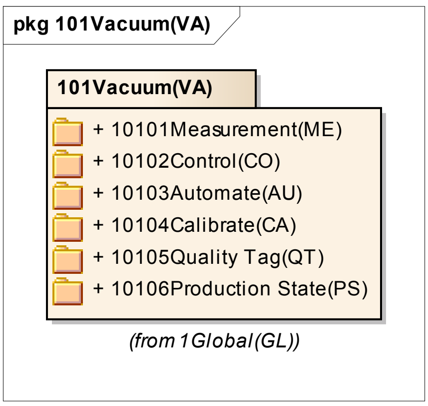

Figure 16: Example of Functional Breakdown at Level 3

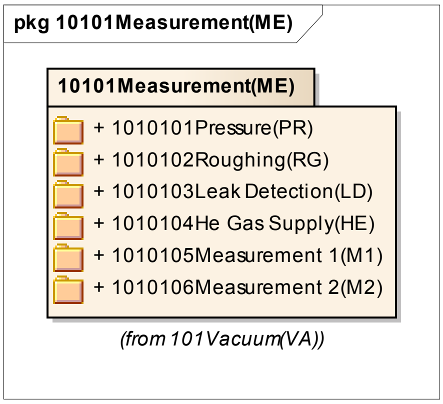

Figure 17: Example of Functional Breakdown at Level 4

Variables are always associated with a function which produces or uses these variables. Implementing variables without the associated functions is not possible. The design must therefore specify the input and output variables of each function.

The variable processing flow diagram describes usage of the variable across the functions. An example is the measurement function such as neutron flux in count mode. For this measurement possible inputs are raw data, calibration coefficient, time stamp, Pulse discrimination parameter and so on.

The possible functions for each inputs are:

- Raw Data – Data Acquisition >> AD Conversion >> Raw Data >> Count Mode
- Calibration Coefficients – Data Processing >> Calibration >> Electronic Calibration >> Calibration Coefficients
- Time Stamp – Data Acquisition >> AD Conversion >> Timing >> Time Stamp
- Pulse Discriminator – Data Processing >> Configuration >> Pulse Discriminator >> Height and Width

The variable exchange diagram for this is as follows:

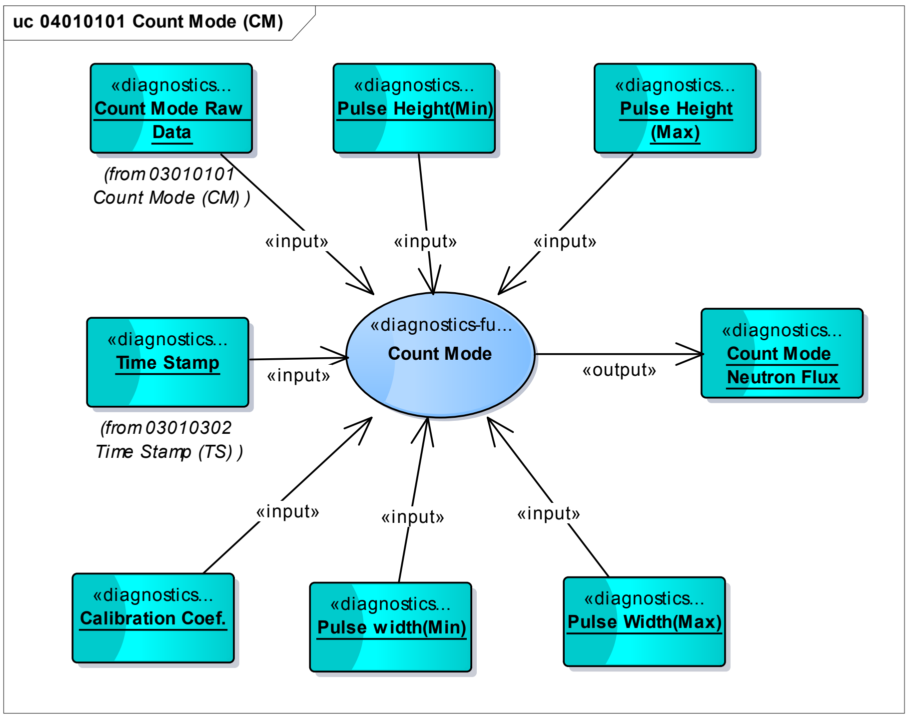

Figure 18: Example of Variable Allocation to Function

Each function of the detailed design is traced to its use cases, user requirements, system requirements, and interfaces with internal and external functions including user interfaces. All functions and their requirements have a unique and structured ID which supports its use in the plant profile database.

SDS - Chapter 5: Plant Automation (PSOS)

This chapter covers

- Detailed Plant System Operating State (DSOS)
- Common Operating State (COS)
- COS-PSOS Mapping
- GOS-PSOS Mapping

For more information please refer to - State Machine Design Guideline [RD12] (ITER_D_UKHVM5)

The example of Plant system operation state and description is shown as per the following Figure 3-13

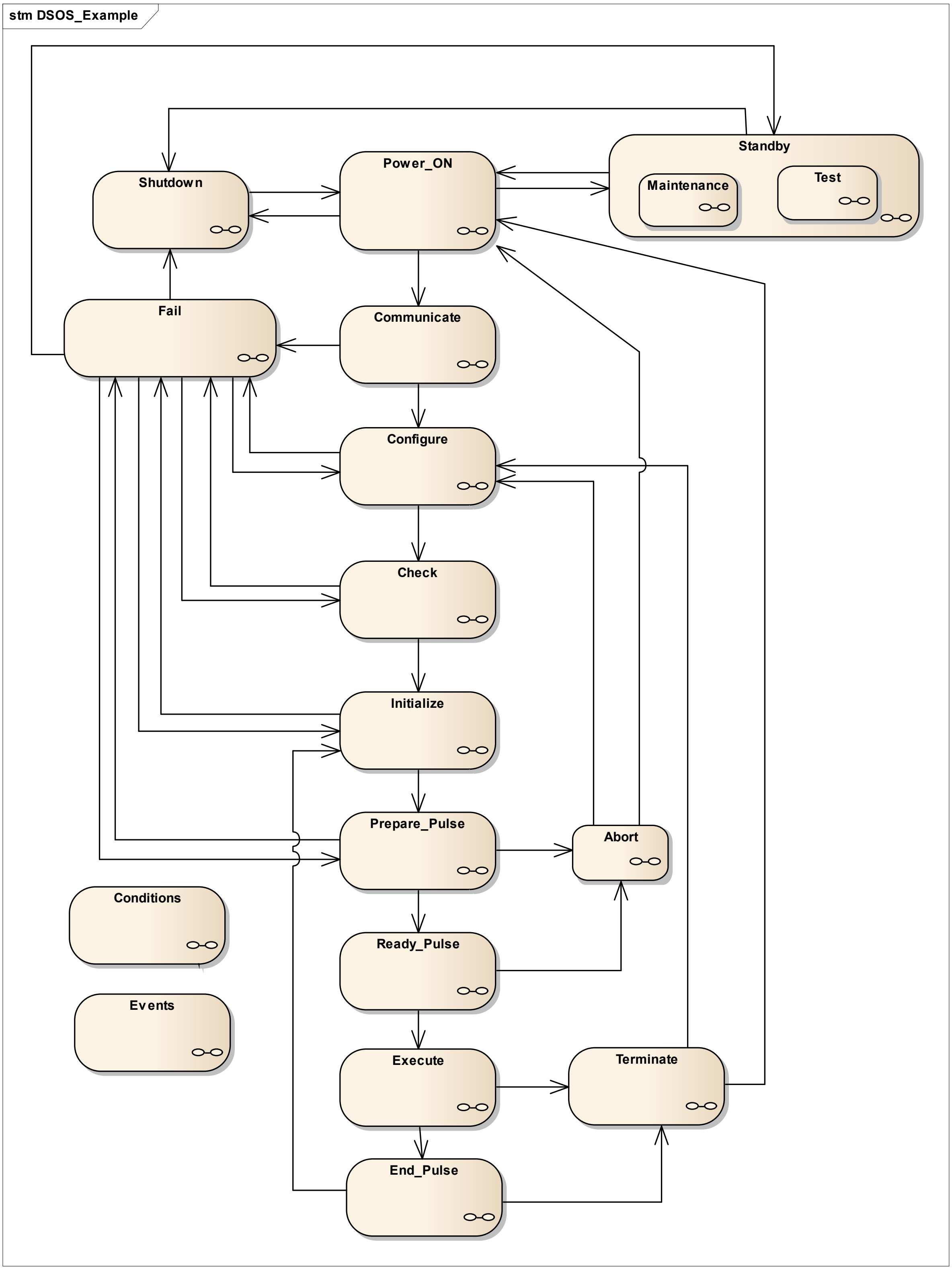

Figure 19: DSOS Example

DSOS Description

Table 36: Example of DSOS State Description

State ID	D1-XX-DSOS-001
State Name	Communicate

State Description	In this state verify the Plant I&C communication (Internal and External)
Entry Procedure	Verify PON Connection
During Procedure	Establish communication with hardware Establish communication with CODAC and CODAC services Establish communication with PCS
Exit Procedure	Report communicate state status
Conditions	[C1] Hardware connectivity shall be OK [C2] Network connectivity shall be OK [C3] CODAC services shall be OK
Events	[E1]. Request received from supervisory system go to Ready [E2]. Hardware connectivity fail [E3]. Network connectivity fail
Time Duration	NA (Requirement to define time duration requited to execute the state)
Inter-Dependencies	PCS must be available
Transitions	If E1, go to Configure If E2, go to Fail If E3, go to Fail
Permission	If executed in manual operation, authorization is required

PSOS-DSOS Mapping

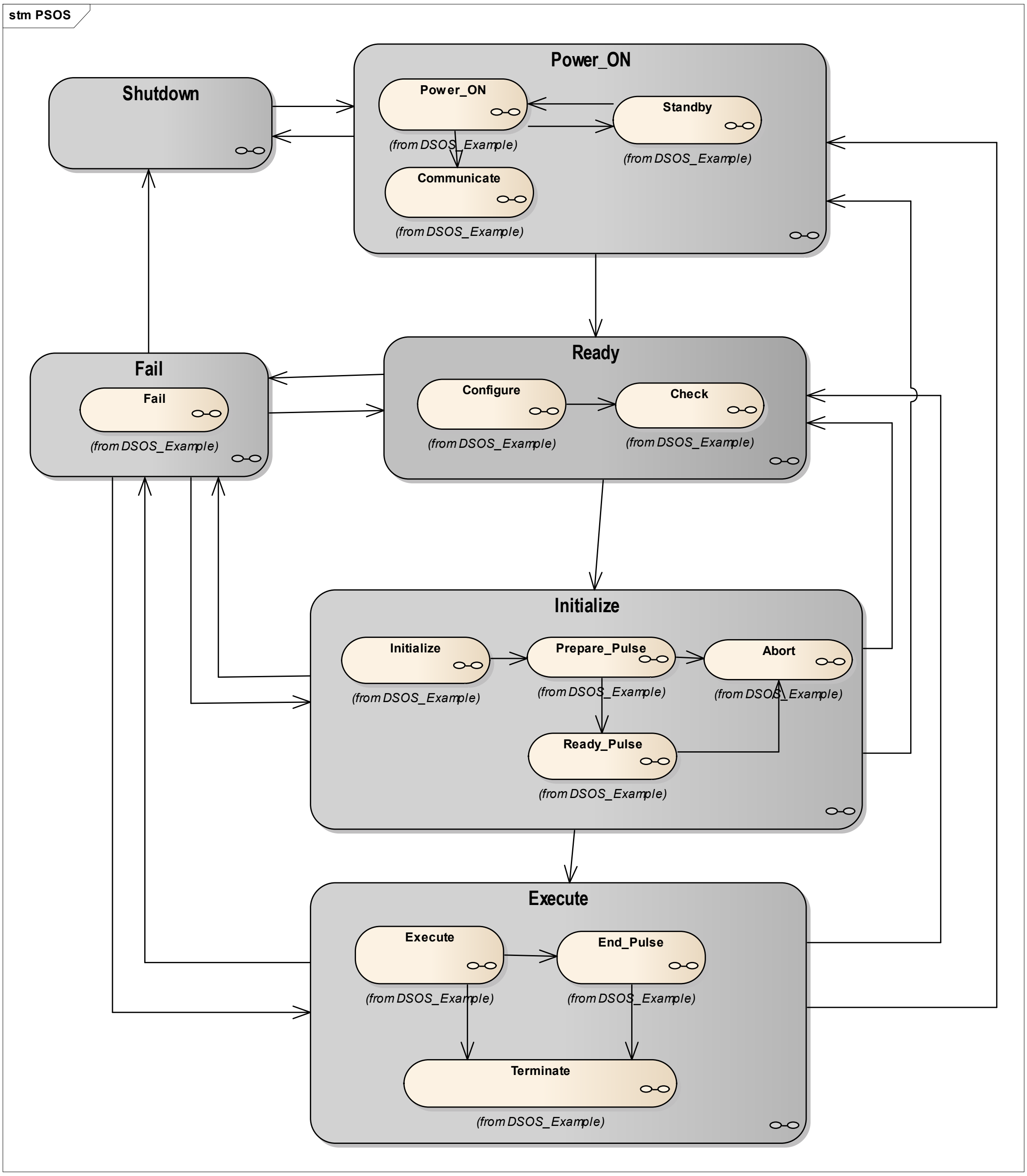

Figure 20: Example PSOS - DSOS Mapping

SDS - Chapter 6: Plant I&C Hardware Architecture

This chapter cover detail Hardware Architecture of Plant I&C. This covers the following topics:

- **Hardware Description -** This section describes the detailed Hardware Architecture. **Error! Reference source not found.** shows the Standard Plant I&C Architecture for ITER. **Error! Reference source not found.** shows the example of Hardware Architecture.
- **Signals and Components Details -** This section describes detailed signals used in plant I&C. It required for follow Plant I&C naming convention for Component and signals
  The details of component naming mentioned in section 4.3.1 of [RD2]

- **I&C Hardware Specification -** This section describes detailed Hardware Specification and BOM.
- **Physical Interface -** This section describe Physical Interface of Plant I&C. **Error! Reference source not found.** shows the example of physical interface.
- **Interfacing of COTS Devices -** This section describe the interface with COTS Devices if any. This will include evaluation of COTS devices and detailed interface to standard I&C devices.

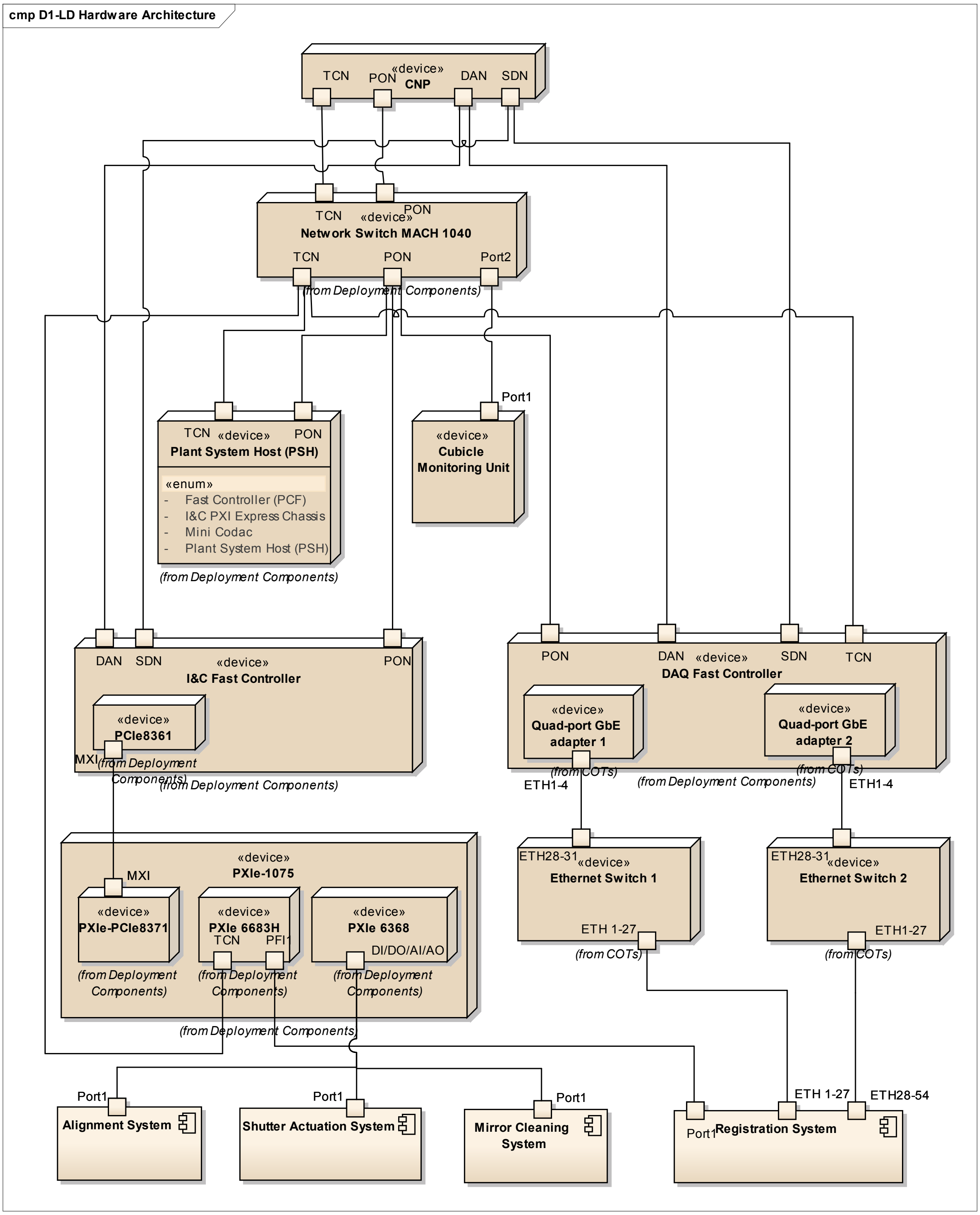

Figure 21: Hardware Architecture

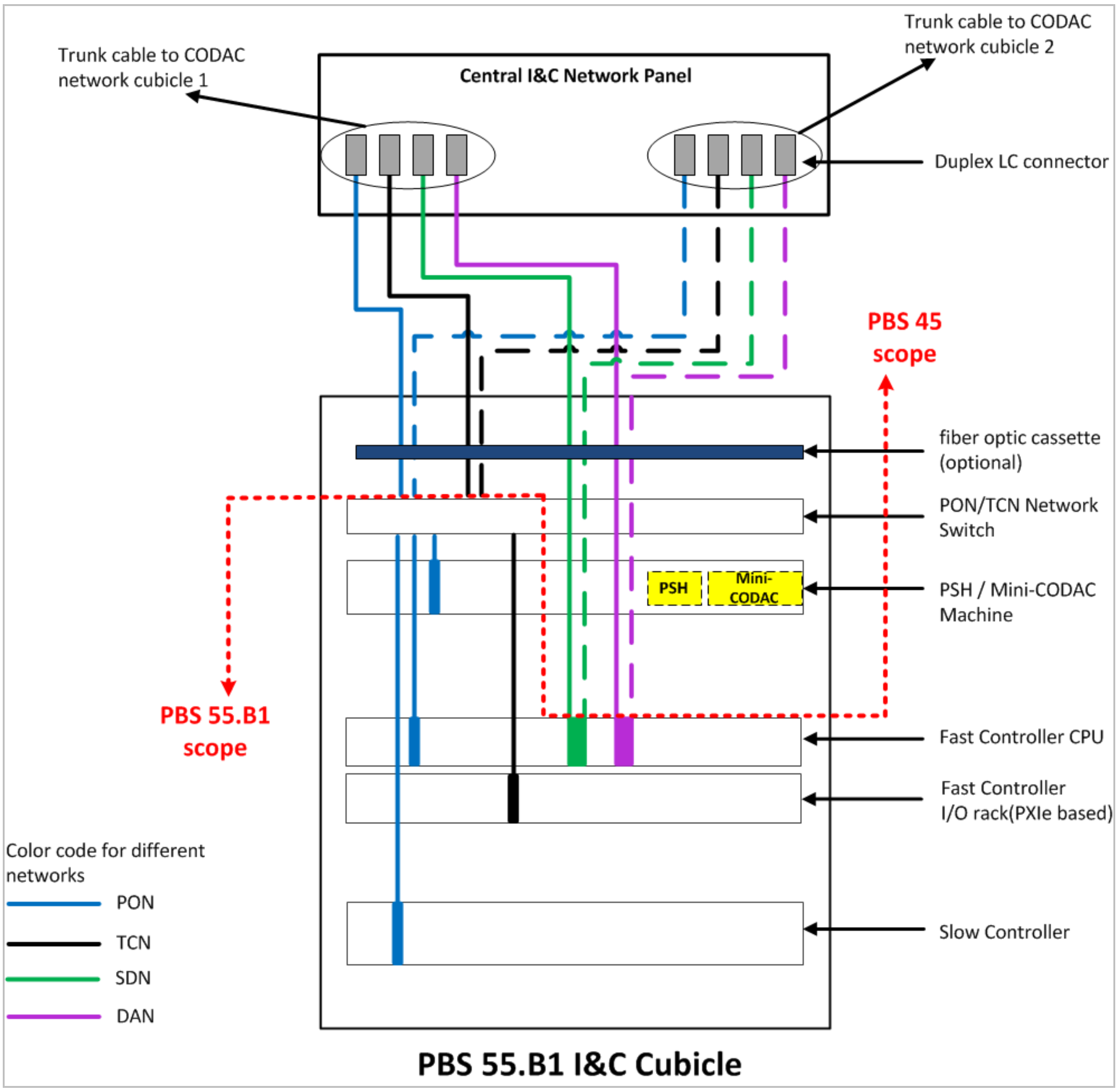

Figure 22: Example Physical Interface with PBS 45

SDS - Chapter 7: Plant I&C Software Overview

This chapter covers following topics:

- **Software Overview -** This section describes software overview for the plant system I&C.
- **Software Modules -** This section describes all software modules will be used in plant I&C design and development.
- **User Interface (HMI) -** This section describes this user interfaces for the plant system I&C.

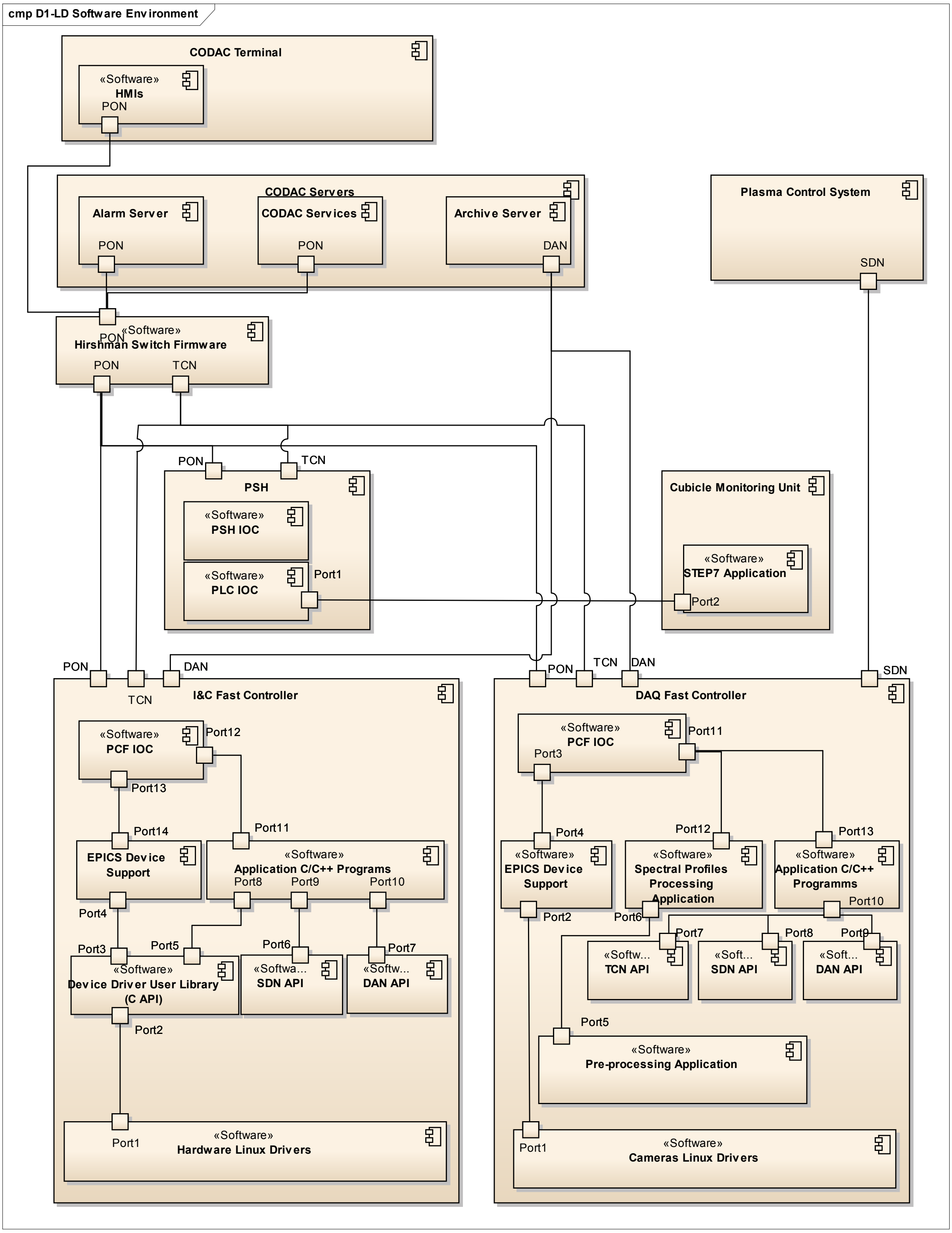

Figure 23: Example of Software Overview

SDS - Chapter 8: Plant I&C Cubicle Configuration

This chapter cover following topics

- I&C Cubicle for Diagnostics System
- Cubicle Specification

- Electrical power load and heat dissipation
- Bill of Material
- Cubicle Locations

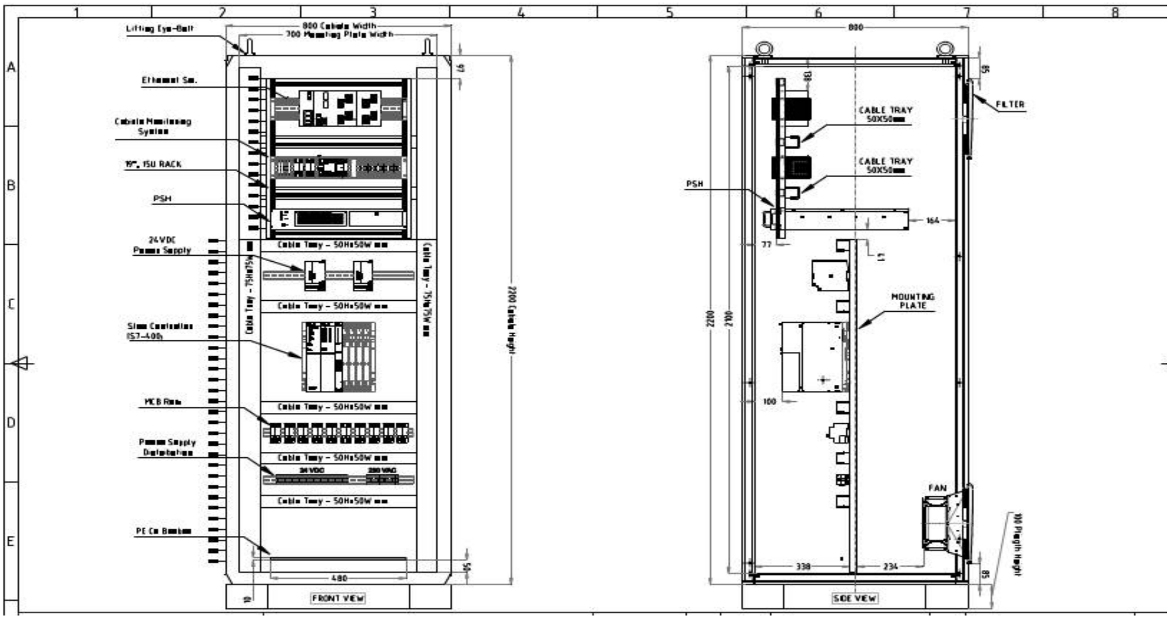

Figure 24: Example of I&C Cubicle Configuration

GLOSSARY

Title	Description
Interface Sheet (IS)	Interface sheet is a document which describes physical interface between two plant system.
Interface data sheet (IDS)	Interface data sheet is a document which describes functional interface between 2 plant systems.
Operations and Maintenance Manual (OMM)	This document is required to be developed during Acceptance Phase or before Operation Phase. This document covers how to Operate Plant System (Automated Operation, Manual Operation) and how to maintain plant system.
System Design Specification (SDS)	The System Design Specification (SDS) is a complete document that contains all the information required to develop the system. Unlike the SRS, the target audience for this document are the implementation and testing teams, so the SDS should be written at a more technical level.
System Manufacturing Specification (SMS)	This document is required to be developed during or before Manufacturing Phase. This document covers implementation of Software (Plant I&C functions, Automation) and manufacturing of Plant I&C Hardware.
System Requirement Specification (SRS)	SRS is a structured collection of information that embodies the requirements of a system.
System Test Plan	A system test plan documents the strategy that will be used to verify and ensure that a system meets its Design Specifications and Requirements. System Test plant will be used for FAT, SAT, Integration testing.
System Test Report	This document will be generated after execution for System Test Plan.
Use Case	A Use Case is a list of action or event steps, typically defining the interactions between a role (known in the Unified Modelling Language as an actor) and a system, to achieve a goal. The actor can be a human, an external system, or time. In systems engineering, use cases are used at a higher level than within software engineering, often representing missions or stakeholder goals. The detailed requirements may then be captured in the Systems Modelling Language (SysML) or as contractual statements. Use cases documentation is a powerful, user-centric method for the system requirements specification process. Use case modelling typically starts from identifying key stakeholder roles (actors) interacting with the system, and their goals or objectives the system must fulfil (an outside perspective). These user goals then become the ideal candidates for the names or titles of the use cases which represent the desired functional features or services provided by the system. This user-centric approach

Title	Description
	ensures that a product of real business value and user requirement is developed, not those trivial functions speculated from a developer or system (inside) perspective.
User Requirement	User Requirements used to specify that how user expects plant I&C systems to be able to do.
System Requirements	System Requirements is a structured collection of information that embodies the requirements of a system. These requirements are implied or transformed from higher-level requirement.
Quality Requirements	Quality of the system refers to the perception of the degree to which the system meets the ITER IO expectations.
Hardware Requirements	Hardware requirements describe hardware specification to operate plant system. Hardware (Architectural) Requirements explains what has to be performed by identifying the necessary systems architecture.
Interface Requirements	Interface Requirements state the required characteristics at a point of connection of the system to the outside world. This describes how the system interfaces with its environment.
Performance Requirements	The extent to which a mission or function must be executed; generally measured in terms of quantity, quality, coverage, timeliness or readiness. During requirements analysis, performance (efficiently it have to be performed) requirements will be interactively developed across all identified functions based on system Life cycle factors; and characterized in terms of the degree of certainty in their estimate, the degree of criticality to system success, and their relationship to other requirements. In order to assess the performance of a system the following must be clearly specified: • Response Time • Workload • Scalability • Platform
Safety-Critical Requirements	Safety Requirements is discipline within systems engineering that lowers the risk of accidental harm to valuable assets to an acceptable level to legitimate stakeholders. Safety requirements optimizes system safety in the design, development, use, and maintenance of software or systems and their integration with safety-critical hardware systems in an operational environment. The ability of the system to operate without catastrophic failure.
Availability Requirements	Describe all of the technical requirements that affect availability such as hours of operation, level of availability required, down-time impact, support availability, and so on. The ability of the system to deliver services when requested
Scalability Requirements	Scalability is the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged in order to accommodate that growth.

Title	Description
Fault Tolerance Requirements	Fault Tolerance is the Requirement that enables a system to continue operating properly in the event of the failure of (or one or more faults within) some of its components
Usability Requirements	Usability is that system designed with a generalized users' psychology and physiology in mind is, for example: More efficient to use—takes less time to accomplish a particular task. Easier to learn— Easy to operate, can be learnt by observing and is user is extremely satisfied.
Operability Requirements	Operability is the ability to keep an equipment, a system in a safe and reliable functioning condition, according to pre-defined Operational Requirements.
Robustness	Robustness is the ability of a system to cope with errors during execution.
Implementation Requirements	Implementation Requirements that enables system to implement plant I&C in a structural manner.
Portability Requirements	The effort required to move the software or hardware or I&C components to a different target platform.
Reliability Requirements	Requirements about how often the system (includes hardware and software) fails. The measurement is often expressed in MTBF (mean time between failures). The definition of a failure must be clear.
Plant system operating state	The correct approach is to define a state machine after having designed all operating procedures, the condition flags which are required to be true for performing these procedures, and the events which trigger state transitions. The states can then be defined in which the procedures can be executed (usually a state is named after the main procedure). For each one defines then the conditions that must be fulfilled and events which trigger the transition.
Condition Flags (SM)	Condition flags are used in a state machine. State machine is required to fulfill the set of conditions (one or more) for being in a state.
Composite State (SM)	Composite state is defined as state that has sub states (nested states)
During Procedure (SM)	During Procedure, which are required to be executed in a particular state.
Entry Procedure (SM)	Entry Procedure or Entry Action which are executed on entry to a particular state. Entry procedure or entry actions are associated with states, not transitions.
Events (SM)	An event is something that happens that affects the system. An event can have associated parameters, allowing the event instance to convey not only the occurrence of some interesting incident but also quantitative information regarding that occurrence.
Exit Procedure (SM)	Exit Procedure or exit actions, which are executed on exit from a

Title	Description
	state. Exit procedure or exit actions are associated with states, not transitions.
Simple State (SM)	A Simple State is a state that does not have sub states.
State Machine (SM)	A State Machine can be defined with multiple states, and each state can have one or more expression rules (Entry Procedure, During Procedure, Exit Procedures, Events, Conditions, Transitions and so on).
Transitions (SM)	A Transition is a directed relationship between a source and a target. It may be part of a compound transition, which takes the State Machine from one State Configuration to another.
Trigger (SM)	Trigger is the cause of the transition, which could be a signal, an event, a change in some condition, or the passage of time.
Fast Controller	Fast Controller is a set of Hardware which consist of CPU, IO Chassis and IO Modules.
I&C Network	Provide physical interface between Central I&C Systems and plant systems I&C. Comprises CODAC Networks, Central Interlock Network and Central Safety Networks. The physical interconnection of devices sharing a communications protocol. In ITER we have PON, DAN, SDN, TCN, CIN, CSN and so on networks.
CODAC Networks	A set of Networks providing the physical and logical interconnection between CODAC System and plant systems I&C. The functions of different CODAC networks include distribution of commands and data exchanges, time and events, plus means of fast synchronous communication. PON, DAN, SDN and TCN are the CODAC networks.
Central Interlock Network (CIN)	Provides the physical interface between Central Interlock System and Plant Interlock System.
Central Safety Networks (CSN)	Provide the physical interface between Central Safety Systems and Plant Safety Systems.
Plant System Host (PSH)	Provides asynchronous communication from CODAC System to Plant Control System and vice versa. Provides command dispatching, state monitoring, data flow and configuration functions.
Plant System Controller	Provides Plant System Specific Data Acquisition, control, monitoring, alarm handling, logging and event handling functions. Interfaces the Central I&C systems through I&C networks and plant system equipment through signals and fieldbuses.