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VERSION CREATED ON / VERSION / STATUS

08 Oct 2024 / 1.1 / Approved

EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical Specifications – DMS PSCC Prototype 1

The purpose of these technical specifications is to outline and define the services and supplies to achieve the first phase of prototyping of the DMS Plant System Conventional Control (PSCC), in view of its manufacturing and integration within the Central I&C Systems.

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1 Preamble

These technical specifications are to be read in combination with [AD1], which constitutes a full part of the technical requirements. In case of conflict, the content of these technical specifications supersedes the [AD1] content.

2 Purpose

The Disruption Mitigation System (DMS) is a key machine protection system for ITER. This system has undergone its Final Design Review (FDR) in March 2024 and it will start its manufacturing phase in 2025. The purpose of these technical specifications is to define the requirements for the Contractor to manufacture specific prototypes of the DMS control system, being compliant with the required standards, when requested. The tasks will also include software programming and the development of test procedures and reports.

3 Acronyms & Definitions

3.1 Acronyms

The following acronyms are the main one relevant to this document.

Abbreviation	Description
AC	Alternating Current
AI	Analogue Input
AO	Analogue Output
APS	Advanced Protection System
BIP	Background Intellectual Property
BOM	Bill of Material
BOY	Best OPI Yet
CAD	Computer Aided Design
CDB	Cryogenic Distribution Board
CE	Conformité Européenne
CIS	Central Interlock System
CM	Closure Meeting
CMS	Cubicle Monitoring System
CODAC	Control, Data Access and Communication
COTS	Commercial-Off-The-Shelf
CP	Communication Processor
CRN	Contractor Release Note
CRO	Contract Responsible Officer
CSS-OS	Central Safety System for Occupational Safety
CS-Studio	Control System Studio
DAP	Delivery At Place
DC	Direct Current
DI	Digital Input
DMS	Disruption Mitigation System
DO	Digital Output
DR	Deviation Request
DRR	Delivery Readiness Review
EA	Enterprise Architect
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EP	Equatorial port
ESB	Emergency-Stop Button
EXW	External Works
FDR	Final Design Review
FIP	Foreground Intellectual Property
FPGA	Field Programmable Gate Array
GIP	Generated Intellectual Property

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GM3S	General Management Specification for Service and Supply
HiL	Hardware-in-the-Loop
HMI	Human-Machine Interface
ICM	Injector Control Module
ICS	Interlock Control System
IDM	ITER Document Management
INB	Installation Nucléaire de Base
IO	ITER Organization
IP	Intellectual Property
IPR	Intellectual Property Rights
ISS	Interspace Support Structure
I&C	Instrumentation & Control
I/O	Input / Output
KOM	Kick-off Meeting
KVM	Keyboard, Video and Mouse
LPM	Local Protection Module
MC	Manchester Coding
MIP	Manufacturing and Inspection Plan
MRR	Manufacturing Readiness Review
MoMs	Minutes of Meeting
NC	Normally Close
NCR	Non Conformance Report
NO	Normally Open
N/A	Not Applicable
PIN	Plant Interlock Network
PLN	Plant Local Network
PN	Part Number
OPD	Optical Pellet Diagnostics
OPI	Operator Interface
OS	Occupational Safety
PBS	Plant Breakdown Structure
PCSS	Port Cell Support Structure
PDR	Preliminary Design Review
PFM	Pellet Firing Module
PIA	Protection Important Activity
PIC	Protection Important Component
PIS	Plant Interlock System
PLC	Programmable Logic Controller
P&ID	Piping & Instrumentation Diagram
PM	Progress Meeting
PN	Part Number
PRO	Procurement Responsible Officer
PSCC	Plant System Conventional Control

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PSH	Plant System Host
PTP	Precision Time Protocol
PWM	Pulse-Width Modulation
QP	Quality Plan
RGA	Residual Gas Analyser
SAT	Site Acceptances Test
SCU	Signal Conditioning Unit
SDN	Synchronous Databus Network
SDS	System Design Specification
SiL	Software-in-the-Loop
SMF	Static Magnetic Field
SRS	System Requirement Specification
STP	System Test Plan
TBC	To Be Confirmed
TBD	To Be Defined
TMP	Turbo Molecular Pump
TRO	Technical Responsible Officer
TTL	Transistor-Transistor Logic
UP	Upper Port
V&V	Verification & Validation

3.2 Definitions

Site or ITER Site or IO Site: Covers the Construction site and Areas under Operation. By extension, any place where IO staff is operating on a regular basis is to be considered ITER Site, if specified as such by IO.

Offsite: Anywhere that is not ITER Site.

Contractor: Shall mean an economic operator who have signed the Contract in which this document is referenced.

4 Applicable Documents & Codes and Standards

4.1 Applicable Documents

It is the responsibility of the Contractor to identify and request for any documents that would not have been transmitted by IO, including the below list of reference documents.

These technical specifications take precedence over the referenced documents. In case of conflicting information, it is the responsibility of the Contractor to seek clarification from IO.

Upon notification of any revision of the applicable document transmitted officially to the Contractor, the Contractor shall advise within four weeks of any impact on the execution of the contract. Without any response after this period, no impact will be considered.

Reference	IDM ID	Version
[AD1] General Management Specification for Service and Supply (GM3S)	82MXQK	1.4
[AD2] Requirements for Producing an Inspection Plan	22MDZD	3.7
[AD3] Procedure for Inspection and Testing	TVL3Y5	2.0
[AD4] Working Instruction for Manufacturing Readiness Review	44SZYP	5.0
[AD5] Working Instruction for the Delivery Readiness Review (DRR)	X3NEGB	2.0
[AD6] Procedure for Management of Nonconformities	22F53X	9.1
[AD7] Requirements for Producing a Contractors Release Note	22F52F	5.0
[AD8] Procedure for the management of Deviation Request	2LZJHB	8.1
[AD9] Requirements for Producing a Contractors Release Note	22F52F	5.0
[AD10] Delivery Report Template	WZPYVZ	3.0
[AD11] Package & Packing List Template	XBZLNG	2.2
[AD12] Template - Equipment Storage & Preservation Requirements Form	WU9636	4.3
[AD13] ITER Procurement Quality Requirements	22MFG4	5.1
[AD14] Requirements for Producing a Quality Plan	22MFMW	4.0

Table 1: Applicable documents

4.2 Applicable Codes and Standards

This is the responsibility of the Contractor to procure the relevant Codes and Standards applicable to that scope of work.

Reference	IDM ID	Version
[CS1] IEC 61508 – Functional safety of electrical / electronic / programmable electronic safety-related systems	N/A	2010
[CS2] IEC 61131-3 – Programmable controllers - Part 3: Programming languages	N/A	2013

Table 2: Applicable codes and standards

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5 Scope of Work

5.1 Introduction

This section defines the specific scope of work for the service, in addition to the contract execution requirement as defined in [AD1].

5.1.1 The DMS System

The purpose of the ITER DMS is to provide machine protection in order to reduce the detrimental effects of plasma disruptions and to ensure the appropriate lifetime of all affected ITER components. It utilizes cryogenic hydrogen and neon pellets which are generated inside the injectors, which are located in the Interspace Support Structure (ISS). These pellets are pneumatically propelled, in the period of milliseconds, towards the plasma and, just before entering the plasma, they are shattered into small fragments so as to reduce damage to the plasma facing components and to other structures inside the ITER tokamak. The DMS is located in ITER ports on the equatorial and the upper levels (see an example of the DMS integrated in the Equatorial Port (EP) #2 in Figure 1). All DMS units on the equatorial level share a common and modular design and so do the units on the upper ports.

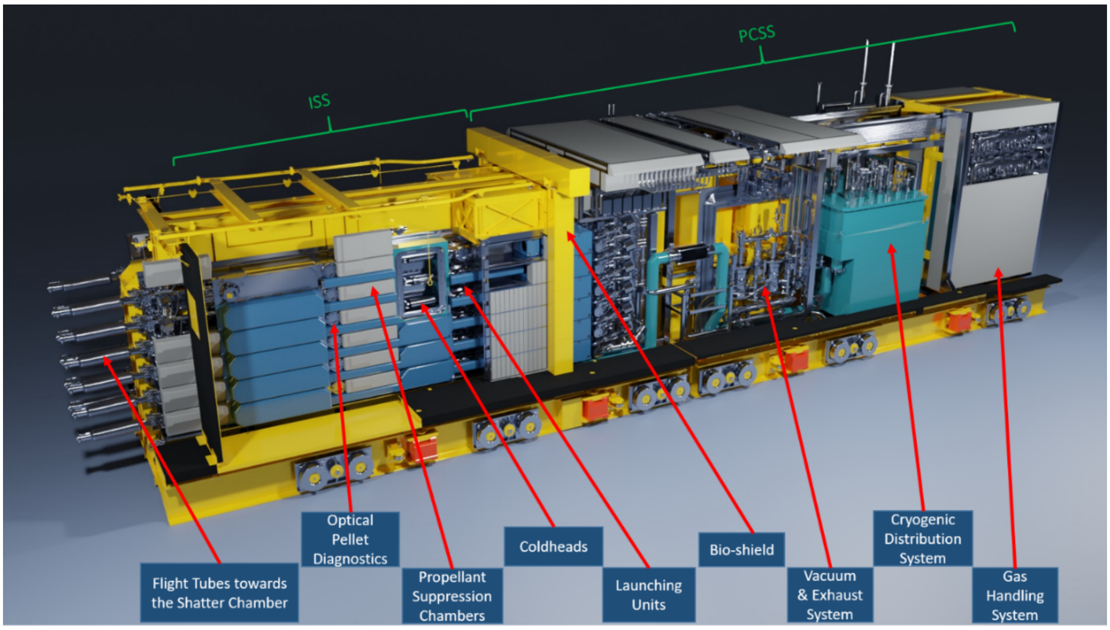

Figure 1: Part of the DMS located in EP #02 with its integration into the ISS and PCSS

The ITER DMS is a large system with a total of twenty-seven injectors distributed toroidally and poloidally in EP #02, EP#08, EP#17 and upper port (UP) #02, UP#08, UP#14. The DMS units are called banks. The EP ones have six injectors each, while the UP ones have only one injector each. As a consequence, the EP banks are four and the UP ones three. Each bank is hosted in a port cell, except for EP#02, which hosts two banks. Each bank has a number associated within a port cell; it can be '1' or '3'. These numbers are shown in Figure 5.

The ITER DMS system can be broken down into a series of work packages such as the Pellet Injector, Cryogenic System, Gas Handling System, Vacuum System and the Control System as shown in Figure 2. Each of these work packages can be broken down further into individual components or assemblies.

The work package of interest for this contract is the Control System, which deals with the design and manufacturing of the DMS instrumentation and control (I&C) system. The I&C system, whose effectiveness is vital for the DMS operation, spans from the most sensitive components located close to the vacuum vessel up to the control cubicles located in the tokamak, assembly and diagnostics buildings (B11, B13 and B74 respectively) and is subject to tough environmental constraints mostly related to ionizing radiations and electro-magnetic fields.

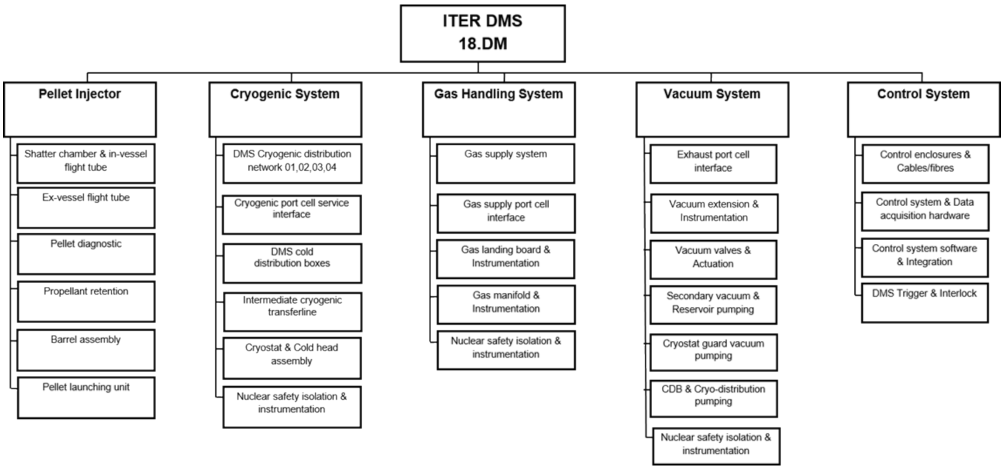

Figure 2: DMS plant breakdown

5.1.2 *DMS I&C System Overview*

The DMS I&C system is composed of two systems:

- The Plant System Conventional Control (PSCC), based on slow controllers, whose main purpose is to generate pellets.
- The Plant Interlock System (PIS), based on fast controllers, whose purpose is to mitigate disruptions and runaway electrons by launching the selected pellets into the plasma.

The ITER guidelines for designing a PSCC can be found in [I01] and in [I02]. For what concerns the PIS, the ITER guidelines can be found not only in [I01] but also in [I03].

The next figure presents the high-level physical architecture of the DMS I&C, based on the PSCC and the PIS. The plant system host (PSH), which is part of the DMS I&C, is the main interface with the CODAC (Control, Data Access and Communication) system through the Plant Operation Network (PON). The PIS is interfaced with the Central Interlock System (CIS) through the Central Interlock Network for Protection (CIN-P), even if it has an interface with CODAC, through the PON, for exchange of non-critical data. The picture also shows that the PIS is interfaced with the Central Safety System for Occupational Safety (CSS-OS) and with the Central Safety System for Nuclear (CSS-N). The picture does not show the communication links, within the Interlock Control System (ICS), which are used to trigger the DMS PIS during a pulse.

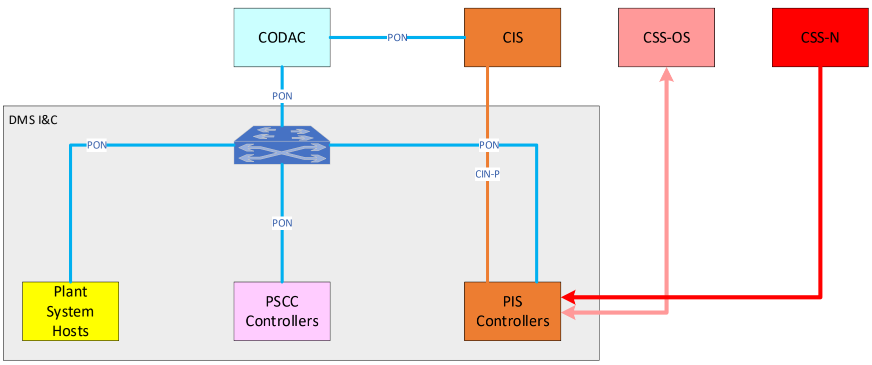

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Figure 3: DMS I&C physical architecture

The next figure allows highlighting which central networks the DMS I&C system is connected to. Indeed not only the PON and CIN-P are used, as previously seen, but the PIS also relies on the Time Communication Network (TCN), for high-performance synchronization, and on the Data Archiving Network (DAN), for high-performance data archiving.

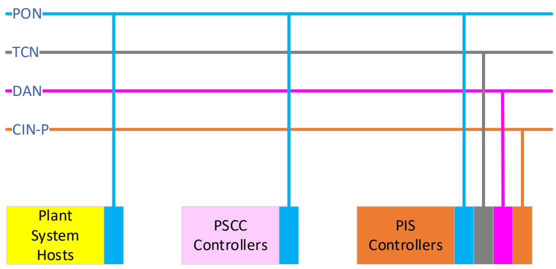

Figure 4: DMS I&C system network connections

5.1.3 DMS I&C System Interfaces

The DMS is interfaced with different systems. In particular, for what concerns the I&C, it is worth highlighting the following interfaces:

- The Vacuum System (PBS 31) in relation to:
  - The Service Vacuum System [I07].
  - The Front End Cryopumps Distribution System and the Cryogenic Guard Vacuum System [I08].
  - The Vacuum Supervisory Control System [I09].
  - The Type-2 Vacuum System [I10].
- The Tritium Plant (PBS 32) in relation to:
  - The Storage Delivery System [I11] for what concerns the supply of gas for the pellet formation and for the propellant valve.
- CODAC (PBS 45) [I12], since it coordinates the PSCC.
- The CIS (PBS 46) [I13], since it coordinated the PIS.
- The Plasma Control System (PBS 47) in relation to:
  - The functional interface with the Advanced Protection System (APS) [I14].
- The CSS-N [I15].
- The CSS-OS [I16].

The CSS-N and the CSS-OS have in particular an impact on the DMS PIS.

5.1.4 DMS I&C Hardware Architecture

The hardware architecture of the DMS I&C is shown in the next figure. The control system, involving PSCC and PIS, is composed in total of fifty-two cubicles. The PSCC cubicles are represented in blue while the PIS cubicles in yellow. The architecture has a kind-of matrix structure.

On the horizontal direction the cubicles associated to each bank are shown. Each bank is independent of the others and under the control of nine cubicles, five of which belong to the PSCC and four to the PIS. The PSCC cubicles belonging to each bank are controlled by a master controller, which is a programmable logic controller (PLC). The PIS cubicles are not independent, meaning that they are under the coordination of two redundant PIS cubicles, the 8101 and 8102. The PIS cubicles 8001 and 8002 contain the hardware used to activate the power supplies hosted in the PIS 8301 and 8302 cubicles and which are used to trigger the

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injectors. The redundant PIS cubicles 8001 and 8002 are, in particular, interfaced with the APS, which is used to dispatch the triggering commands to the DMS. For what concerns the terminology, the 8001 and 8002 cubicles are called pellet firing modules (PFMs), the 8101 and 8102 cubicles are called injector control modules (ICMs) while the rest of the PIS cubicles are called local protection modules (LPMs). The PIS is based on fast controllers and is not in the scope of these technical specifications.

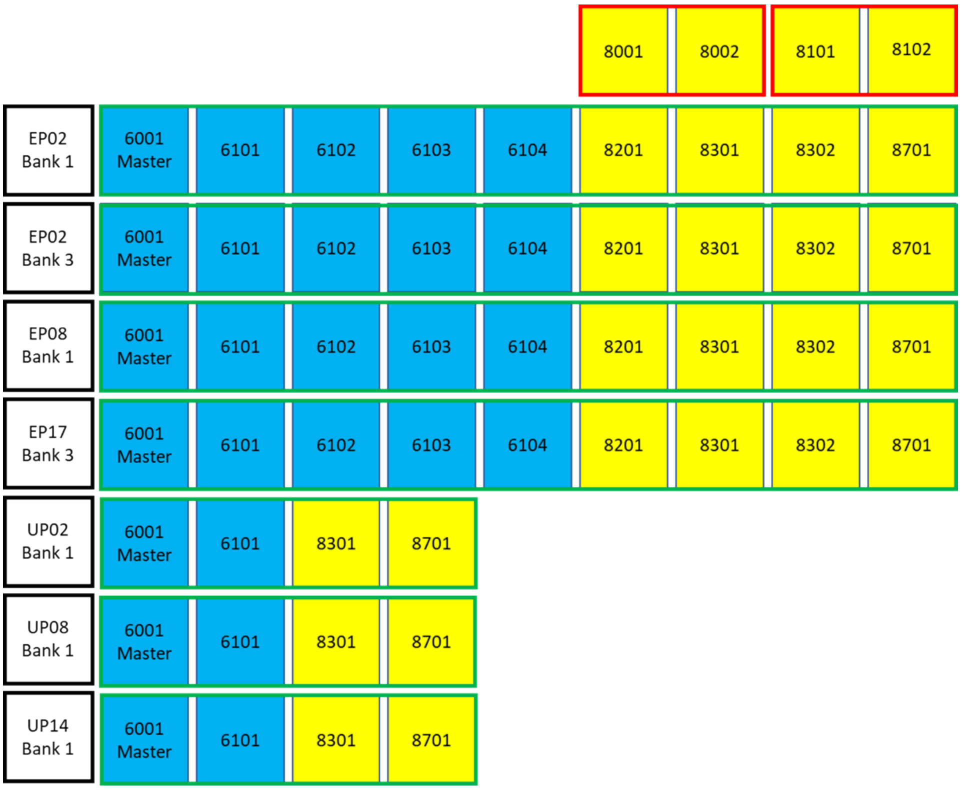

Figure 5: DMS I&C hardware architecture

The full DMS I&C architecture is shown in the next figure.

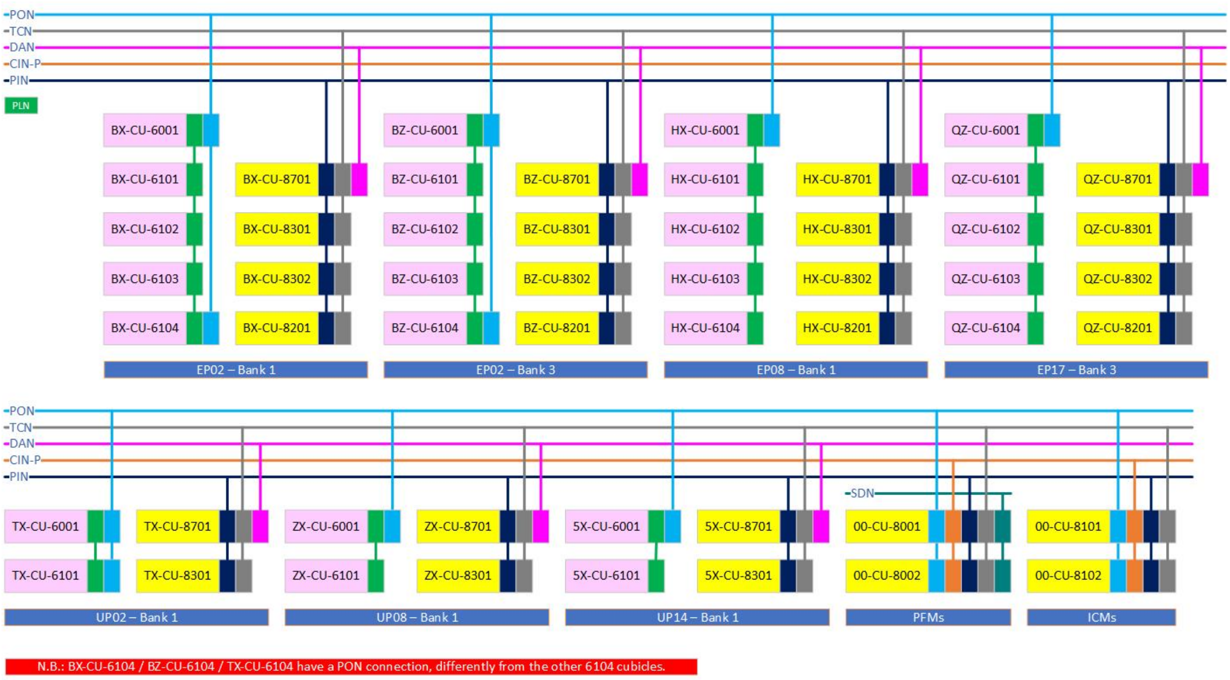

Figure 6: Full DMS I&C architecture

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Some new networks are introduced:

- The Plant Interlock Network (PIN), used to interface the LPMs and PFMs with the ICMs.
- The Plant Local Network (PLN), which is the PSCC local network.
- The Synchronous Databus Network (SDN), which is only used by the APS, which is redundant and physically located in the 8001 and 8002 cubicles.

The PIN and SDN are out of the scope of these technical specifications. A PLN shall be deployed by the Contractor to interface the three cubicles under the scope of Lot 2.

5.2 Preliminary Technical Information for the Service Supply

1) In order to support the deliverables, the Contractor shall use, when requested, the Control-System Studio (CS-Studio) suite, which is part of the CODAC Core System and included in the Mini-CODAC tool to develop a basic human-machine interface (HMI), based on the display manager BOY (Best OPI Yet), where OPI means Operator Interface. Linux RedHat shall be the operating system, as per [I01].
2) In the framework of Lot-2 services, the Contractor shall consider a transmission rate of 10 Hz both for the input and output signals. Alternative solutions shall be agreed with the IO Technical Responsible Officer (TRO).

5.3 Scope of Service #1 (Lot 1)

5.3.1 Description

According to [I01], the I&C cubicle must have a cubicle monitoring system (CMS). IO supplies a CMS integration kit, but its usage is not mandatory. Details of this integration kit can be found in the IDM folder [I17] and in [I18]. Additional useful information can be found in [I19].

The purpose of the Lot-1 service is to provide a CMS solution alternative to the one proposed by IO, which is less consuming in terms of space in the cubicle but still compliant with the same requirements, i.e.:

- Availability of two 24 VDC digital input (DI) signals to monitor the status of the cubicle front and rear doors.
- Availability of one 24 VDC DI signal to monitor the status of the cubicle fan.
- Availability of one 24 VDC DIs to monitor the status of an occupational-safety (OS) emergency-stop button (ESB).
- Availability of one 0-10V analogue input (AI) signal for PT100 temperature probes to monitor the cubicle temperature.
- Availability of one 24 VDC digital output (DO) to power the cubicle fault-status led.
- Availability of spare DI, AI and DO signals.
- Availability of an Ethernet port for data exchange with the plant system host (PSH) [I01] via TCP/IP/
- Refresh rate: 2Hz.
- Compliance with the system health monitoring variables [I20].

To this purpose, in order to easy the integration of the CMS into the CODAC environment, IO shall supply the Contractor, as free-issue items, with an I&C Integration Kit [I19] composed of the Mini-CODAC tool [I01], the IO CMS and the Hirschmann MACH102 network switch. The Mini-CODAC tool will also contain a PSH, for the interface with CODAC. IO will also provide, as example, a survey on some possible solutions that can be used to develop the alternative CMS [I21]. Ideally, the CMS prototype will have to be mounted on a DIN rail and with a height of at most 2U.

It is worth highlighting that, with respect to the CMS proposed by CODAC, there is one additional input. This is due to the fact that some of the DMS cubicles are OS relevant and so equipped with an OS ESB. This button has redundant wires and its status will not only be acquired by the Central Safety System for Occupational Safety (CSS-OS) but also by CODAC so as to be displayed in the control room.

Lot-1 deliverables are described in Appendix 1 – Lot-1 Deliverables. It is foreseen that the purchase of some items shall be agreed with the IO TRO.

5.4 Scope of Service #2 (Lot 2)

5.4.1 Description

The first purpose of the Lot-2 services is to reproduce at full scale three cubicles of the DMS PSCC related to the control of an EP bank, with all the required components:

- The 6001 cubicle, which is the cubicle hosting the bank master controller and mainly devoted to the control of the bank common components and of the bank cryogenic distribution board (CDB).
- The 6101 cubicle. In the DMS PSCC this cubicle is equivalent to the 6102 and 6103 cubicles, each of which controls two injectors.
- The 6104 cubicle, which is the cubicle hosting equipment having distance constraints from the field devices.

The cubicles, which will be powered with 230 VAC power supply, shall be procured by the Contractor using the following specifications:

- Cubicle supplier: Schneider Electric [I23].
- Cubicle type: Control cubicle.
- Cubicle model: NSYSFHFRSTVEB.
- Cubicle description: Floor standing, electro-magnetic compatibility (EMC) protection, 1-2 kW heat dissipation capacity (850 m^3/h fan), 4x19” uprights, 47U.
- Dimensions (mm): 2200 (H) x 800 (W) x 800 (D).

The cubicles shall be procured through the Schneider Electric website specifically created for IO, available at https://iter.se.com/. An account will have to be created. Through the order, all the elements necessary to assemble the cubicles will be provided, including two limit switches for the front and rear doors, indicator lights (green and red), and a temperature probe (PT100). However, the Contractor shall also procure:

- A temperature display per cubicle, to be placed externally on the front door of the cubicle.
- An OS ESB to be placed into the 6001 cubicle. An example of OS ESB is the following:
  - Siemens 3SU1801-0NE00-4AB2, with two normally closed (NC) and one normally open (NO) contacts. One NC contact shall be connected to one CMS DI.

The lights and the temperature display shall be placed on the front door as in the following figure (please note that in this figure there is one additional green light, which is not needed for the prototypes):

Figure 7: Front-door layout of the cubicle prototypes

The Contractor shall make the cutouts in the cubicle doors. The cubicles shall also have the CE marking and the electrical tags. The cubicle functional reference tag is not needed for the prototypes.

An example of front-door component wiring is shown in the following figure:

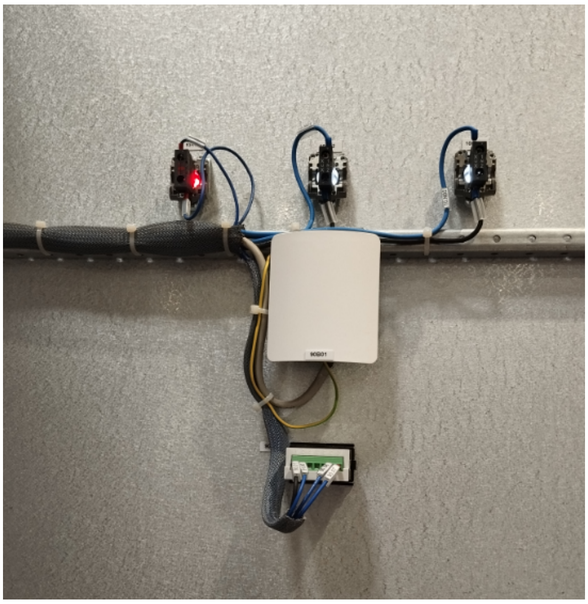

Figure 8: Front-door component internal wiring example

The DMS PSCC will use specific signal conditioning units (SCUs) for the integration of its instrumentation within the control system. The SCUs to be integrated in the DMS PSCC and mounted in the cubicles are the following:

- Inficon TPG500 Passive Gauge Controller suitable for 19" rack with the following boards [I31]:

  - CP300 T11L for Pirani and cold cathode measurement (two boards).
  - IF301P for Profibus-DP communication.

  The SCU is also equipped with an Ethernet port on the main chassis.
- Gantner Q.raxx slimline A105-16CR DP – Netic [I32]:
  - This SCU, suitable for 19” rack, has been expressly developed for the ITER environment. It has sixteen AI channels for cryogenic temperature sensors and a Profibus-DP interface.
- Cryomagnetics, Inc. LM-510-11-3 Liquid Cryogen Level Monitor, with the two-channel option [I33]:
  - For the signal acquisition the two analogue output (AO) signals shall be used, using the 0-10V signal range. The SCU will be provided with the 19” rack mountable cabinet option.
- Opsens Solutions CoreSens SCU [I34], suitable for 19” rack and with a special configuration shielded from electro-magnetic interferences (EMIs), expressly developed for ITER, it can be equipped with the following boards:
  - CSC-M communication module with Ethernet interface for configuration and data exchange via a controller (master chassis) and with Ethercat interface for data exchange with the slave chassis.
  - CSC-B communication module with Ethercat interface for data exchange with the master chassis.
  - WLX-2S optical modules.
  - ODG-HC heater controllers.
- Hiden Analytical devices [I35] for HAL 101X RC residual gas analyser (RGA) control, composed of:
  - One RC control interface unit with 19” rack mountable cabinet option.
  - One remote RF generator with preamplifier with 19” rack mountable cabinet option.

The DMS PSCC will also use ad-hoc regulators to control specific actuators. The regulators to be integrated in the DMS PSCC and mounted in the cubicles are the following:

- Osaka Vacuum, Ltd. devices [I36] for turbo molecular pump (TMP) TG420MRCNB control equipped with RS-232 communication with the PSCC controller and composed of:
  - One Turbo Controller unit TC010MA-31 with 19” rack mountable cabinet option.
  - One Repeater unit RBR-1-150 with 19” rack mountable cabinet option.
- TDK Lambda Z+ power supplies, suitable for 19” rack [I37] and to be used with heaters for the control of the temperature on the cryogenic system. There will be two kinds of power supplies, depending on the heater to be actuated:
  - Z60-3.5 for heaters up to 50W.
  - Z320-1.3 for heaters up to 150W.

  The power supplies will be connected via an RS-485 daisy-chain communication to the controller.

Additionally, the following regulations will have to be implemented:

- The control of solenoid valves from Burkert (https://www.burkert.com/):
  - Type: 2873.
  - Part Number (PN): 319046.

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While Burkert supplies its own controller for the control of this kind of valve, which is implemented via pulse-width modulation (PWM), in the DMS PSCC the Burkert controller has to be replaced with a Siemens PWM module, like the one proposed below.

- The rough control of cryogenic heaters and of the baking heater using a phase-control module from Siemens, like the one proposed below.
- The on-off control of isolation valves via Siemens DO modules, like the one proposed below.
- The control of the cryogenic proportional Velan valves ACRG.
  The most common solution to control these valves is through Siemens SIPART PS2 drawer [I38] for 19" rack. For the DMS, one 5-channel QRL module (the positioner) for the control of pneumatic actuators is sufficient. The drawer has a Profibus PA interface, which means that a Profibus DP/PA converter is needed to interface the drawer with the controller. The output of the positioner is used to control a piezo-pneumatic pilot valve from Hoerbiger [I38], whose modulated compressed air controls the Velan valve. There are two of such valves in the DMS process.

The second purpose of the Lot-2 services is to demonstrate the effective integration of SCUs and regulators within the DMS PSCC. This task shall imply the set-up of the interfaces for configuration and data exchange.

The Contractor will have to assemble all the devices in the cubicles, including the DMS PSCC controller, the remote I/O (input / output) modules, the SCUs / regulators and the CMS prototypes developed through the Lot-1 services.

The PSCC controller will be actually constituted of a set of components from Siemens, as per [I24], distributed across the three cubicles, involving a PLC and some remote I/O. Generally speaking, the type of Siemens components will be part of the following list:

Component	Type	Part Number
S7-1500 PLC	S7-1500 PLC, CPU 1516-3 PN/DP	6ES7516-3AN02-0AB0
ET 200SP Remote I/O	IM155-6PN ST	6ES7155-6AU01-0BN0
ET 200SP Bus Adapter	BA 2xRJ45	6ES7193-6AR00-0AA0
Power Supply	PM 1507 24 V/8 A	6EP1333-4BA00
ET 200SP DI Card	DI 16x 24V DC ST, PU 1	6ES7131-6BH01-0BA0
ET 200SP DO Card	DQ 16x 24V DC/0,5A ST, PU1	6ES7132-6BH01-0BA0
ET 200SP AI Card	AI 8XI 2-/4-Wire Basic	6ES7134-6GF00-0AA1
ET 200SP PT100 AI Card	AI 4xRTD/TC 2-/3-/4-Wire HF	6ES7134-6JD00-0CA1
ET 200SP Relay Module #1	RQ NO 4x120VDC-230VAC/5A	6ES7132-6HD01-0BB1
ET 200SP Relay Module #2	RQ CO 4x 24V DC/2A	6ES7132-6GD51-0BA0
ET 200SP PWM Module	TM Pulse 2x24V PWM	6ES7138-6DB00-0BB1
ET 200SP Power Control Module	DQ 4x24-230VAC/2A HF	6ES7132-6FD00-0CU0
ET 200SP Communication Module	CM PTP	6ES7137-6AA01-0BA0
Field Device DP/PA Coupler	FDC 157	6ES7157-0AC85-0XA0

Table 3: List of Siemens components to be used for the PSCC and available in [I24]

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The Contractor shall get the specific datasheets of the Siemens components from the Siemens website.

IO shall supply the Contractor with the following free-issue items:

- The SCUs (including controllers and modules).
- The regulators.
- All the custom cables from sensors/actuators to SCUs/regulators, if needed.
- All the custom cables from SCUs/regulators to the Siemens devices.
- Valves and pilot valves, if needed by the test benches.

The Contractor shall evaluate the choice of the Siemens components proposed by IO and assess their correctness or not, based on the project requirements. In case, the Contractor shall propose alternative Siemens components.

The Contractor shall procure the Siemens components in agreement with the IO TRO. This task should be performed as far as possible in the shortest delay, to take into account the time to execute the remaining tasks. It shall be duty of the Contractor to estimate the cost of such components in the tender phase and to include their cost in their financial offer.

The Contractor shall complete the cubicle with:

- The ordinary AC and DC power distribution as per [I18], guaranteeing adequate protection to all the devices, the grounding, and the powering of all the devices (either 230 VAC or 24 VDC) and by using the outputs of the Siemens relay module to control the power of the devices inside the cubicles.
- All the ordinary cables, communication networks and components necessary to complete a control cubicle. It shall be duty of the Contractor to estimate such components in the tender phase and to include their cost in their financial offer.
- A 19” laptop tray to be placed in the middle of the 6001 cubicle. This tray shall be used to support a maintenance laptop, which will be connected to the network switch in the same cubicle and with which to access all the devices in the plant local network (PLN), especially the commercial-off-the-shelf (COTS) ones which cannot be directly interfaced with CODAC.

The 6001 cubicle shall be also equipped with the aforementioned Hirschmann MACH102 network switch from the I&C Integration Kit, which will be used for the connection with the Mini-CODAC tool, located outside of the cubicle.

IO shall supply the Contractor with a preliminary cubicle layout (if available), with the list of types and PNs of each SCU/regulators and related sensors/actuators and with the list of signals associated with each cubicle, when relevant.

Lot-2 deliverables are described in Appendix 2 – Lot-2 Deliverables. As aforementioned, it is foreseen that the purchase of some items shall be agreed with the IO TRO.

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5.5 Scope of Service #3 (Lot 3) – Optional

5.5.1 Preamble

The services to be provided under this lot are optional. The IO TRO shall decide during the contract execution if these services shall be requested or not. However, the Contractor, when preparing the offer to the tender in the scope of these technical specifications, shall also provide a quotation for the services of this lot.

5.5.2 Description

The purpose of Lot-3 services shall be to provide a simulator of the DMS process, which eventually will be used to tune and test the DMS control software and its future modifications.

The simulation shall not be used to reproduce behaviour of the DMS when it is triggered, but to simulate the pellet generation process and all the rest of slow processes which are under the responsibility of the DMS PSCC. Ideally, the DMS process should be subdivided into subsystems, as those identified in [I44], and for each of these subsystems its sensors and actuators shall be identified. Moreover, this service shall also include the simulation of the CDB process and the flow of the gas throughout the pipes. It is important to remind that while an EP bank has one common non-cryogenic system and one common cryogenic system for six injectors, an UP bank has one common non-cryogenic system and one common cryogenic system only for one injector. The exact boundary conditions however shall be established together with the IO TRO and the IO process engineers at the beginning of the contract.

In order to perform the Lot-3 services, IO shall supply the EP08 master piping and instrumentation diagrams (P&IDs): [I45], [I46], [I47] and [I48]. Moreover, the Contractor shall consider the following documents describing the process and the DMS operation: [I49], [I50], [I51] and [I52]. IO shall also supply the PSCC functional specifications [I53].

The simulator shall be developed using the Siemens simulation platform, composed of:

- SIMIT v11.2 (or higher) as simulation tool.
- SIMATIC S7-PLCSIM Advanced v6.0 (or higher) as virtual controller.

The Contractor shall provide the software tools and the due licences. All shall be IO property and given back to IO at the end of the contract.

SIMIT is a powerful simulation platform developed by Siemens that enables the virtual commissioning and testing of automation systems. It is widely used in various industries to simulate, test and validate control systems before they are deployed in real-world environments. SIMIT helps to enhance the efficiency, reliability and safety of automation projects by providing a virtual environment where different components and systems can interact and be tested comprehensively. There are two available concepts for a plant simulation:

Software-in-the-loop (SiL): The SiL concept completely replaces the real automation hardware (AS in the following figure) with software. A typical architecture employing PLCSIM and SIMIT is shown hereafter:

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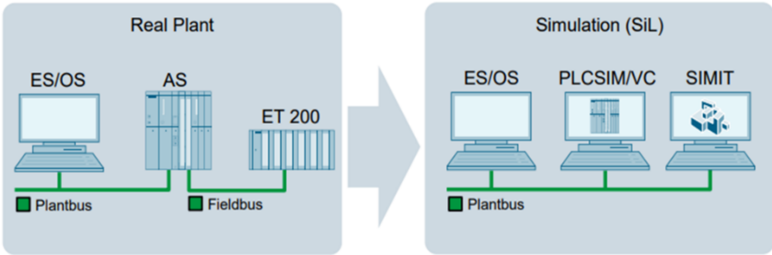

Figure 9: SiL simulation architecture with SIMIT

Hardware-in-the-loop (HiL): The HiL concept is a combination of a real automation hardware and a simulation of components and physical processes. The following figure shows the HiL structure with a real automation hardware (AS), simulated field devices (SU, SIMIT Unit) and the simulated process (SIMIT).

PLCSIM Advanced is a Siemens tool that simulates PLCs in a virtual environment, allowing engineers to develop and debug control systems without physical hardware. It supports complex automation testing and integrates with various software components, validating control logic and communication protocols. SIMIT uses the "PLCSIM Advanced" coupling to communicate with PLCSIM Advanced over a software interface of PLCSIM Advanced. SIMIT uses the PLCSIM Advanced coupling to cyclically exchange data of the I/O area of the configured S7-1500 stations. SIMIT supports up to 16 stations.

The Contractor shall implement the SiL architecture by using SIMIT to simulate the process and PLCSIM Advanced to implement the functions controlling the process. The Contractor is free to develop an HMI, if deemed useful, to exchange input data and configuration parameters with PLCSIM Advanced, but this will be free of charge for IO.

The Contractor shall get the specific datasheets of the Siemens components from the Siemens website. IO shall provide the due licences and the laptop where to run the tool.

Just to give a rough idea of the amount of signals to deal with, there are approximately:

- 120 I/O signals per injector.
- 220 I/O signals for the auxiliary systems, i.e. CDB, gas handling system and vacuum system.

Despite the fact that the master DMS bank is the EP#08 one, equipped with six injectors, the scope of this lot shall be limited to a generic UP bank. Therefore only the simulation of one injector shall have to be developed and the common parts (cryogenic and non-cryogenic) shall be interfaced to only one injector. However the Contractor shall structure the simulation to include up to six injectors in the loop.

Lot-3 deliverables are described in Appendix 3 – Lot-3 Deliverables.

6 Contract Execution

6.1 Contract Implementation

The Contractor shall implement the contract according to the contract gates listed in Section 10.1. These contract gates shall include the manufacturing readiness reviews (MRR) and the delivery readiness review (DRR).

6.2 Time Schedule

The duration of all the activities is summarized in the following list:

- Lot 1: 3 months.
- Lot 2: 9 months.
- Lot 3: 9 months.

6.3 Location for Scope of Work Execution

The Contractor shall perform the work at their own location.

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7 IO Documents & IO Free Issue Items

7.1 IO Documents

Under this scope of work, IO will deliver the following documents by the stated date:

Reference	IDM ID	Expected date
[I01] Plant Control Design Handbook	27LH2V	Contract start
[I02] Plant System I&C Architecture	32GEBH	Contract start
[I03] Guidelines for the Design of the Plant Interlock System (PIS)	3PZ2D2	Contract start
[I04] ITER catalogue for I&C products - Slow controllers PLC	333J63	Contract start
[I05] ITER Catalog of I&C products - Fast Controllers	345X28	Contract start
[I06] ITER catalogue for I&C products - Cubicles	35LXVZ	Contract start
[I07] IS-18.DM-31.SV-001 Physical and functional interface between Disruption Mitigation System and Service Vacuum System	Q68WVW	Contract start
[I08] IS-18.DM-31-002 Connection between 31 (FECDS and CGVS) and 18.DMS	PS6Y63	Contract start
[I09] IS-18.DM-31-003 Interface between Disruption Mitigation System and Vacuum Supervisory control System	5DPZFH	Contract start
[I10] IS-18.DM-31-005 Interface between Disruption Mitigation System and Vacuum Exhaust System	39PUJE	Contract start
[I11] IS-18.DM-32.SD-001 Physical & Functional Interface between the DMS and the Storage Delivery System	2UYEVP	Contract start
[I12] IS-18.DM-45-001 Interface between DisrupMitig System (18.DM) and the CODAC (45)	UAZ4XV	Contract start
[I13] IS-18.DM-46.01-001 Interface between FWC –Disruption Mitigation System and CIS - Investment Protection System	QBU8HB	Contract start
[I14] IS-47-18.DM-005 Functional interface between PBS47-PCS and PBS18 Disruption Mitigation system	TQSG26	Contract start
[I15] IS-18.DM-48.01-001 Nuclear safety Interface between the Disruption Mitigation System and the Central Safety System	V3EL2W	Contract start
[I16] IS-18.DM-48.02-001 Occupational safety Interface between Disruption Mitigation System and the Central Safety System	V3EM99	Contract start
[I17] ITER Design Cubicle Monitoring System – IDM folder	PPA5LG	Contract start
[I18] I&C cubicle internal configuration	4H5DW6	Contract start

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[I19] Technical specifications For Plant System I&C - Integration Kits and Cubicle Monitoring/Slow Controller Deployment	FURZX9	Contract start
[I20] System Health Monitoring Variables	35XFCY	Contract start
[I21] Cubicle Monitoring System Survey	BBVBX7	Contract start
[I22] I&C_Integration_kit_CUBHMU_Field IO_Test_Plan	QUP5HU	Contract start
[I23] ITER catalogue for I&C products - Cubicles	35LXVZ	Contract start
[I24] ITER catalogue for I&C products - Slow controllers PLC	333J63	Contract start
[I25] EDH Part 1: Introduction	2F7HD2	Contract start
[I26] EDH Part 2: Terminology & Acronyms	2E8QVA	Contract start
[I27] EDH Part 3: Codes & Standards	2E8DLM	Contract start
[I28] EDH Part 4: Electromagnetic Compatibility (EMC)	45B523E	Contract start
[I29] EDH Part 5: Earthing and Lightning Protection	4B7ZDG	Contract start
[I30] EDH Guide A: Electrical Installations for SSEN Systems	2EB9VT	Contract start
[I31] Datasheets of the Inficon TPG500 controller and associated boards	N/A	Contract start
[I32] Datasheets of Gantner Q.raxx slimline A105-16CR DP – Netic SCU	N/A	Contract start
[I33] Datasheets of Cryomagnetics, Inc. LM-510 Liquid Cryogen Level Monitor SCU	N/A	Contract start
[I34] Datasheets of Opsens Solutions CoreSens SCU	N/A	Contract start
[I35] Datasheets of Hiden Analytical devices	N/A	Contract start
[I36] Datasheets for Osaka Vacuum, Ltd. devices	N/A	Contract start
[I37] Datasheets of TDK Lambda power supplies	N/A	Contract start
[I38] Datasheets of Siemens SIPART PS2 and Hoerbiger	N/A	Contract start
[I39] Datasheets of Burkert valve	N/A	Contract start
[I40] CODAC Core System Overview	34SDZ5	Contract start
[I41] Plant system I&C Integration plan	3VVU9W	Contract

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		start
[I42] Self-description Data Documentation and Guidelines	34QXCP	Contract start
[I43] CODAC DDD	6M58M9	Contract start
[I44] SRD-18-DM (Disruption Mitigation System) from DOORS	BEJQWA	Contract start
[I45] Injector 01 of Bank 1 of Equatorial Port 08 - P&ID	4GKRDP	Contract start
[I46] Common non-cryogenic services and interfaces of Bank 1 of Equatorial Port 08 - P&ID	6R3LHK	Contract start
[I47] Cryogenic distribution system of Bank 1 of Equatorial Port 08 - P&ID	6R3CCX	Contract start
[I48] 18.DM.33 - DMS Cryogenic Network#3	YPQ8NN	Contract start
[I49] DMS Pellet Generation Process Description	5DUSM8	Contract start
[I50] DMS Cold Head design-basis heat loads and cooling requirements	8MGR3U	Contract start
[I51] DMS cryogenic instrumentation and heaters selection and justification	9H7DXG	Contract start
[I52] System Concept of Operations for DMS	5A7CTG	Contract start
[I53] DMS PSCC Functional Specifications	Not yet available	Contract start
[I54] DMS I&C sub-DDD	APXLPZ	Contract start

7.2 Free Issue Items

Under this scope of work, IO will deliver the following equipment/parts by the stated date:

Equipment / Part Description	Part Number	Expected date
CODAC I&C Integration Kit	N/A	As soon as possible
Inficon TPG500 passive gauge controller	IO398400	Contract Start
Inficon 19" rack	IT491211	Contract Start
Inficon Pirani / cold cathode measurement board CP300 T11L	IO441120	Contract Start
Inficon interface and relay board IF 301 P	IO441396	Contract Start
Inficon Pirani gauge head TPR 018	IOG15020	Contract Start
Inficon 3m cable for Pirani gauge AM_LM4	BG548308-T	Contract Start
Gantner Q.raxx slimline A105-16CR DP – NETIC	TBD	Contract Start
Cryomagnetics, Inc LM-510	LM-510-11-3 (TBC)	Contract Start

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Opsens CoreSens chassis 13 modules – ITER version CSC-4U-S13-EU-IT	AR01762 (or 1782 TBC)	Contract Start
Opsens master EtherCat card CSC-M	AR01592	Contract Start
Opsens card W LX-2S-P-N-62LCA-V3 for 0-10V analogue outputs	AR01593	Contract Start
Opsens CoreSens 2-channel heater controller module ODG-HC for ODG pressure sensor	AR01779	Contract Start
Opsens connector	TBD	Contract Start
Opsens special cables	TBD	Contract Start
Hiden Analytical 19" rack mountable HAL 101X RC control interface unit	TBD	Contract Start
Hiden Analytical 19" rack mountable HAL 101X RF generator with preamplifier	TBD	Contract Start
Hiden Analytical special cables	TBD	Contract Start
Osaka Vacuum 19" rack mountable TC010MA-31 turbo controller	TBD	Contract Start
Osaka Vacuum 19" rack mountable RBR-1-150 repeater unit	TBD	Contract Start
Osaka Vacuum special cables	TBD	Contract Start
TDK Lambda Z+ low-voltage programmable power supply	Z60-3.5	Contract Start
TDK Lambda Z+ high-voltage programmable power supply	Z320-1.3	Contract Start
TDK Lambda six-unit 19" housing rack	Z-NL100	Contract Start
TDK Lambda special cables	TBD	Contract Start
Burkert valve type 2873	319046	Contract Start
Velan valve or equivalent	TBD	Contract Start
Hoerbiger P13 piezo-pneumatic pilot valve	TBD	Contract Start
Siemens SIPART PS2 (Optional)	TBD	If and When Needed During the Contract

N.B.: The exact number of free issue items and the missing part numbers shall be provided by the contract start or when the information is available. Material handover forms shall be used to clearly list the free issue items provided by IO to the Contractor and vice versa at the end of the contract.

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8 List of Deliverables and Due Dates

8.1 List of Deliverable Documentation

The Contractor shall provide IO with the documents and data required in the application of this technical specification, of [AD1] and any other requirement derived from the application of the contract. A minimum, but not limited to, list of documents is available hereafter with associated due dates. The Contractor is requested to prepare their document schedule based on what follows and using the template available in the [AD1] appendix II (click here to download). In the following tables, T0 is the Commencement Date of the contract and X the number of months starting from T0.

8.1.1 List of Lot 1 Deliverables

Technical Design Family (TDF)	Generic Document Title (GTD)	Further Description	Expected date (T0+X)
Instrumentation and Control Document	Instrumentation and Control - Physical and Functional Architecture	CMS Technical Specifications	1
Acceptance Record or Report	Factory Acceptance Test Report-FATR	CMS Manufacturing I	2
Design Description	Software Architecture Design Document-SADD	CMS Software Specifications	3
Software or Programming Code	Product Software	CMS Software Programming	3
Acceptance Record or Report	Factory Acceptance Test Report-FATR	CMS Integration	3
Acceptance Record or Report	Factory Acceptance Test Report-FATR	CMS Manufacturing II	3

8.1.2 List of Lot 2 Deliverables

Technical Design Family (TDF)	Generic Document Title (GTD)	Further Description	Expected date (T0+X)
Instrumentation and Control Document	Instrumentation and Control - Physical and Functional Architecture	Cubicle Prototype Specifications	2
Acceptance Record or Report	Factory Acceptance Test Report-FATR	Cubicle Prototype Manufacturing	4
Design Description	Software Architecture Design Document-SADD	Cubicle Prototype Software Specifications	6
Software or Programming Code	Product Software	Prototype Software Programming	9
Acceptance Record or Report	Factory Acceptance Test Report-FATR	Cubicle Prototype Integration	9

8.1.3 List of Lot 3 Deliverables – Optional

Technical Design Family (TDF)	Generic Document Title (GTD)	Further Description	Expected date (T0+X)
Engineering Analysis and Calculation Report	Simulation Analysis Report	Process Simulation Framework	3

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Design Description	Software Architecture Design Document-SADD	Simulator Software Specifications	6
Software or Programming Code	Product Software	Bank Simulation	9

8.2 List of Deliverable Items

As part of the deliverables described in the Appendices of these technical specifications, the Contractor shall deliver the following items:

Reference ID #	Description	Quantity	Expected Date (T0+X)
1	CMS	3	3
2	Cubicle Prototype	3	9

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9 General Requirements

9.1 CE Marking

CE marking shall be applied to the cubicle prototypes according to the applicable EU directives.

9.2 Environmental Requirements

The prototypes shall operate in the ambient conditions according to the following table:

Condition	Min	Max
Temperature (°C)	18	35
Atmospheric Pressure (Atm)	1	1
Relative Humidity (%)	30	60

Table 4: Ambient conditions for the cubicle prototypes

9.3 I&C Requirements

The requirements and guidelines mentioned in [I01] and related satellite documents shall apply.

9.4 Manufacturing Requirements

The Contractor shall submit to IO TRO approval a manufacturing and inspection plan (MIP), with control points agreed with the IO TRO, before starting any manufacturing activity. The MIP shall be prepared according to [AD2]. The intervention/control points shall be agreed between the Contractor and the IO TRO before approval of the MIP.

The Contractor shall also organise MRRs, as per Chapter 6 and Section 10.1. Given the Quality Class (QC) mentioned in Section 9.9, these MRRs can be simplified ones.

The Contractor shall also provide a simplified manufacturing dossier for each set of prototypes, composed of:

- The quality plan.
- The complete list of critical sub-contractors, if applicable.
- The final MIP.
- The final documentation schedule.
- The final results summary, incorporating the results of all the acceptance tests and surveys carried out.
- A compilation of all the meeting minutes and reports, of the non-conformance reports (NCRs) and of the deviation requests (DRs).
- The final intellectual property (IP) report summarizing the information on the provided foreground intellectual property rights (IPR) declaration (form to be supplied by IO).
- All the additional documents mentioned in the deliverables (specifications, test reports, etc.).
- Manuals and instructions for the handling, installation, assembly and maintenance of the prototypes.
- Drawings marked and signed as “as built”.

9.5 Factory Acceptance Requirements

The acceptance tests at the Contractor premises are included in the contract deliverables as shown in the appendices.

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9.6 Temporary Storage Requirements

The Supplier shall prepare a preservation plan to ensure temporary storage of the prototypes until delivery to the IO. The preservation plan shall be followed all along the storage period.

9.7 Packaging, Shipping and Delivery Requirements

The prototypes should be shipped assembled as close as possible to the acceptance test configurations. In case a separate shipping is needed, the reassembly procedure and the required tools shall be provided by the Contractor.

The prototypes shall be conditioned/packed for shipping in order to protect them from contamination, handling and shocks. The prototype shall be shipped protected by the atmospheric agents (rain, wind, dust). The prototype shall be transported in the installation orientation and protected from shocks. Shipping impact indicators, like shock watches, shall be used to monitor the possible shocks received by the prototypes during the transportation. These indicators shall be verified by the IO TRO upon prototype delivery and shall contribute to the final acceptance.

Shipment Hold Point shall only be released after completing the DRR.

The following mandatory documents shall be provided in accordance with the DRR working instruction [AD5]:

- Contractor Release Note [AD9].
- Delivery Report [AD10].
- Packing List that reflects the content of the CRN [AD11].
- Equipment Storage & Preservation Requirements Form [AD12].

The relevant templates will be provided by IO in due time.

The DRR documents shall be submitted to IO CRO and to logistics.data@iter.org at least fifteen (15) working days prior to the planned shipment date.

The DRR prepared by the Contractor, shall state as a minimum:

- The packing date.
- The full address of the place of delivery and the name of the person responsible to receive the package, as well as of the Contractor’s name and full address.
- The Bill of Material (BOM).
- The security measures.
- The CRN [AD7].
- The Packing List.
- Any material safety datasheets, if applicable.
- The declaration of integrity of the package.
- The declaration of integrity of the components.
- Any additional relevant information on the status of the components.

The CRN shall be approved by the IO TRO. It shall include links to the already approved manufacturing dossier, and to already approved/closed deviation requests/NCRs. The contractor shall be responsible for delivering to the following IO address:

- ITER Organization, Route de Vinon sur Verdon, 13115 St Paul lez Durance, France.

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The contractor is encouraged to take an appropriate insurance policy coverage against risk of loss or damage to the Items during the transport. The components can be delivered by the logistics service provider of contractor's choice, unless the Incoterm is EXW (in this case the logistic service provider shall be Daher). However, the Incoterm should be preferably CIP.

N.B.: As part of the packaging, shipping and delivery, the Contractor shall also include, at their expenses, all the items provided by IO (see list of free-issue items) and not expressly part of the prototypes, like for instance the Mini-CODAC tool or the IO CMS. These items shall be clearly mentioned in the aforementioned documentation.

9.8 Site Acceptance Requirements

A site acceptances test (SAT) will be performed by IO at the ITER site, within three (3) months after delivery of the prototypes. The Contractor will be allowed to witness the SAT. Positive SAT shall be required for IO final acceptance. The SAT shall include at least:

- Visual inspection before unloading, to assess the package integrity and the number and type of components contained in the shipment.
- Availability of the enclosed documentation required for the shipping.
- Inspection of the shipping impact indicators. If these indicators record shocks above the threshold, a thorough inspection of the components shall be performed. A decision on the acceptance of the delivery of the components will be made by the IO TRO.
- Visual inspection after unpacking.

9.9 Quality Assurance Requirements

The QC under this contract is QC-2. Chapter 8 of [AD1] applies in line with the defined QC.

The quality requirements shall be in accordance with the ITER Procurement Quality Requirements [AD13] and with QC-2.

The Contractor shall not start any work without a Quality Plan (QP) in place that has been accepted by the IO, according to [AD14]. The QP shall be supplied at least two (2) weeks before the contract kick-off meeting (KOM).

The Contractor shall not start any manufacturing without an MIP in place that has been accepted by the IO, according to [AD2].

The list of critical quality activities will be provided by the Contractor for acceptance by IO within the QP, prior to commencing any work.

Major NCRs shall be submitted to the IO NCR database for review and acceptance in accordance with IO procedure.

Minor NCR issued by the Contractor, which are against the contract requirement, international standard or codes, regulatory requirements, shall be submitted to IO for information and validation of remedial actions.

It is agreed that MIPs are used to monitor Quality Control and acceptance tests and must be produced by the Contractor and critical Sub-contractors, unless otherwise agreed between the Parties.

Critical Quality Activities are defined as "any activity or operation that if not performed correctly may affect safety, functionality or reliability". Subcontractors not performing critical quality activities may be exempted from the requirement to produce Quality Plans and MIPs at the discretion of the IO Quality Assurance Responsible Officer. This decision will be dependent on the level of detail about subcontracted work in the Contractors Quality Plan. In such cases, the work can be included in the Contractor's MIP and managed in accordance with the Contractor's management system.

9.10 Change Management

Any changes to the requirements of this contract proposed by either the IO or the Contractor and any unforeseen non-conformities to this contract requirements or to the approved manufacturing design during the course of execution of the contract shall follow [AD8] and [AD6] respectively.

In compliance with [AD6], the IO NCR database shall be used to process the non-conformities.

9.11 Conflict of Interest and Intellectual Property

The Contractor shall declare in advance as part of the tender phase any Background Intellectual Property (BIP) that they might use in the execution of the contract and confirm its usage by the end of the contract, by submitting BIP declaration.

Any design document, drawing, model, analysis, software, test result, not declared as BIP, but generated during the execution of this contract (Generated Intellectual property, GIP) shall be considered property of the IO, with freedom to reuse within the IO project, including the freedom to share with different IO domestic agencies and IO or domestic agency Suppliers.

The IO may reject any offer not in compliance with the above requirements or terminate the Contract if the selected Contractor cannot comply with them.

The IO might decide to protect the GIP according to the rules of the ITER agreement.

9.12 Safety Requirements

No specific safety requirements related to protection important components (PICs) or protection important activities (PIAs) apply.

9.13 Summary

The following table summarizes the general requirements applicable to each lot, highlighting the deviations related to the optional Lot 3:

Requirement Type	Lot 1	Lot 2	Lot 3
CE Marking	Yes, as part of Lot 2	Yes	No
Environmental	Yes	Yes	No
I&C	Yes	Yes	Yes
Manufacturing	Yes	Yes	No
Factory Acceptance	Yes	Yes	Yes
Packaging, Shipping and Delivery	Yes, as part of Lot 2	Yes	No
Site Acceptance	Yes, as part of Lot 2	Yes	No
Quality Assurance	Yes	Yes	Yes
Change Management	Yes	Yes	Yes
Conflict of Interest and Intellectual Property	Yes	Yes	Yes
Safety	Yes (*)	Yes (*)	Yes (*)

(*): In the sense that no specific safety requirement is applicable to any of the lots.

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10 Special Management Requirements

Section 6 of [AD1] applies in full.

10.1 Contract Gates

The contract gates are defined in section 6.1.5 of [AD1]. For what concerns the KOM, it will be organized no later than two weeks after the signature of the contract and it will happen remotely.

10.1.1 Generic Contract Gates

The following generic contract gates shall be respected by the Contractor:

- KOM.
- MRR in the scope of deliverable L1-D2.
- MRR in the scope of deliverable L1-D6.
- MRR in the scope of deliverable L2-D2.
- DRR in the scope of Lot 1 and Lot 2.
- Close-out as per [AD1].

10.1.2 Lot 1 Contract Gates

Lot 1 shall have the following technical gates, listed in chronological order:

- Approval of deliverable L1-D1 by the IO TRO.
- Approval of deliverable L1-D2 by the IO TRO.
- Approval of deliverable L1-D3 by the IO TRO.
- Approval of deliverable L1-D4 by the IO TRO.
- Approval of deliverable L1-D5 by the IO TRO.
- Approval of deliverable L1-D6 by the IO TRO.

10.1.3 Lot 2 Contract Gates

Lot 2 shall have the following technical gates, listed in chronological order:

- Approval of deliverable L2-D1 by the IO TRO.
- Approval of deliverable L1-D5 by the IO TRO (needed because of the CMS).
- Approval of deliverable L2-D2 by the IO TRO.
- Approval of deliverable L2-D3 by the IO TRO.
- Approval of deliverable L2-D4 by the IO TRO.
- Approval of deliverable L2-D5 by the IO TRO.

10.1.4 Lot 3 Contract Gates (Optional)

Lot 3 shall have the following technical gates, listed in chronological order:

- Approval of deliverable L3-D1 by the IO TRO.
- Approval of deliverable L3-D2 by the IO TRO.
- Approval of deliverable L3-D3 by the IO TRO.

10.2 Work Monitoring

As stated in [AD1], the work progress will be managed as explained in sub-sections 6.1.4 for progress reports and 6.1.6 for progress meetings (PMs). It is duty of the Contractor to organise the progress meeting, preferably one week in advance of the deliverable expected dates, and to properly prepare and upload the progress minutes in IDM.

Moreover, the work monitoring can also be complementary achieved through the formal exchange of documents transmitted by emails or over IDM.

10.3 Meeting Schedule

In addition to the PMs, the Contractor shall work closely with the engineers from PBS 18.DM and also of other PBSs if needed. Routine technical meetings will take place to monitor work progress and approaches, discuss and decide on technical solutions, provide additional information, address hold points, and identify actions which require follow-up. These meeting will have an agenda. Actions/issues identified in these meetings will be recorded and reviewed in subsequent meetings until completed/resolved. It is duty of the Contractor to properly prepare and upload in IDM the minutes of these meetings. The minutes will comprehend at least a list of the closed, open and new actions, together with their description and the person in charge.

On request and by agreement, additional special subject meetings will be organized.

10.4 CAD design requirements

This contract does not imply CAD activities that request the connection to one of the ITER project CAD databases.

10.5 Specific Requirements and Conditions

In order to complete the tasks in a timely manner, the following is required:

- The Contractor shall provide a team with qualified and experienced persons in order to perform efficiently all the required tasks. In particular, the Contractor personnel deployed for this task order shall satisfy the requirements and criteria listed in the following bullets. The Contractor shall establish a management and records system to demonstrate staff member level of experience, including educational qualifications, work experience and training. Records shall be kept by the Contractor and provided to IO upon request. The Contractor shall present to the IO, for each lot, the *curriculum vitae* of one named individual for each level of expertise requested and shall identify for each a substitute capable of replacing him/her in case of absence. If qualified, one person may be identified for up to two roles. These individuals shall not be changed during the period of execution of the contract, unless agreed with IO. For all the lots, the strategic functions per level of expertise are:
    - Confirmed I&C Engineer (5-10 years)
    - Senior I&C Engineer (> 10 years)
- The Contractor shall be experienced in writing technical documents and proficient in English. It is required that the Contractor, according to the criteria mentioned in Chapter 9, puts in place a rigid and efficient internal procedure for the verification of the deliverables, in order to guarantee a high-quality standard. It is reminded to the Contractor that the purpose of IO, when reviewing deliverables, is to focus on the technical part only. The IO TRO might reserve the right not to approve deliverables if they are judged to have a poor quality.
- The Contractor shall be a proven expert in the design, development and prototyping of I&C systems (requirements, functional specifications, hardware and software architectures and specifications, programming, test plans and reports, assembly, maintenance, etc.) for conventional control systems.

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- The Contractor shall be an experienced user of the Siemens components.
- The Contractor shall have experience about the use of instrumentation and regulators for process control (pressure sensors, temperature sensors, SCUs, valve actuation, power regulators, etc.)
- The Contractor shall be proficient in all programming languages listed in the IEC 61131-3 standard.
- The Contractor shall be experienced in assessment of the design compliance with technical requirements.
- The Contractor shall work independently with minimum supervision to achieve the objectives and deliverables specified in this technical specification.
- The Contractor shall have the proper qualifications and habilitations in order to work with the equipment, in particular the electrical ones.
- In their financial offer, the Contractor shall clearly state the cost of all the software and hardware components they will have to buy in order to provide the CMS prototype, the cubicle prototypes and, optionally, the simulation tool.

11 Appendix 1 – Lot-1 Deliverables

11.1 L1-D1: CMS Technical Specifications

The Contractor shall provide the technical specifications of the CMS prototype, which have to be compliant with requirements mentioned in the previous sub-section. This document shall contain:

- The CMS prototype hardware and software architecture.
- The CMS wiring diagram. The wiring diagram shall be produced using See Electrical Expert from IGE+XAO (https://www.ige-xao.com/en/us/see-electrical-expert/), the software for electrical engineering adopted by IO. The See Electrical Expert file shall also be provided in the scope of this deliverable.
- The BOM.

All the documents shall be provided in the form of a .zip file.

11.2 L1-D2: CMS Manufacturing I

The Contractor shall procure the due components and manufacture the CMS prototype according to the L1-D1 specifications, provided that they have been approved by the IO TRO. The list of the components to be purchased will have to be agreed by the IO TRO. The Contractor shall provide the IO TRO with the equipment delivery note. A plan for the continuity test shall also be provided, including grounding tests.

Before starting the CMS manufacturing, the Contractor shall organise a simplified manufacturing readiness review (MRR) according to [AD4]. Approval of the MRR report by the IO TRO shall be the criterion to start the CMS manufacturing.

This deliverable shall be considered achieved upon:

- Acceptance by the IO TRO of the delivery note, which shall be in line with the financial offer (see Section 10.5).
- Acceptance of the CMS manufacturing by the IO TRO and positive outcome of the continuity tests, captured in a continuity test report.

11.3 L1-D3: CMS Software Specifications

In compliance with [I19] and [I20], the Contractor shall provide the CMS prototype software specifications, including:

- The software architecture.
- Procedures for installations of hardware and software packages, if any.
- Mini-CODAC tool configuration, as required for the integration and tests of the CMS prototype, if relevant.

All the documents shall be provided in the form of a .zip file.

11.4 L1-D4: CMS Software Programming

Upon IO acceptance of L1-D3 and based on the L1-D3 specifications, the Contractor shall:

- Program the CMS controller.
- Upload the source code in svnpub, the CODAC Subversion server, using a naming convention agreed with IO. The link to the source code in svnpub shall be provided to IO.
- Provide the Self-Description Data (SDD) as per [I42].

SERVICE

The acceptance of this deliverable is subject to the positive outcome of deliverable L1-D5.

11.5 L1-D5: CMS Integration

The Contractor shall integrate the CMS prototype into the CODAC environment using the Mini-CODAC tool. To this purpose, the Contractor shall provide a CMS prototype test plan and a CMS prototype test report. An example of test plan, that can be adapted to the context, is provided in [I22]. The integration shall include the development of user software, i.e. of an HMI with BOY, to support the test results. The source code of the HMI shall be uploaded in svnpub. The link to the source code in svnpub shall be provided to IO. This deliverable shall be considered achieved upon acceptance of the test report by the IO TRO.

11.6 L1-D6: CMS Manufacturing II

Upon IO acceptance of L1-D5, the Contractor shall manufacture two additional CMSs, by purchasing all the missing components, providing the IO TRO with the equipment delivery note and the plan for the continuity test, including grounding tests.

Before starting the manufacturing, the Contractor shall organise a simplified MRR according to [AD4]. Approval of the MRR report by the IO TRO shall be the criterion to start the manufacturing of the two additional CMSs.

After the manufacturing of the two additional CMSs, the Contractor shall:

- Provide the continuity test reports of both CMSs, using the aforementioned test plan, with positive outcome.
- Program the CMS controllers.
- Perform the integration of the CMSs and provide the integration test reports of both CMSs, with positive outcome.

The deliverable shall be considered achieved upon acceptance of the equipment delivery note, which shall be in line with the financial offer (see Section 10.5), and of all four test reports by the IO TRO.

12 Appendix 2 – Lot-2 Deliverables

12.1 L2-D1: Cubicle Prototype Specifications

The Contractor shall provide:

- The BOM of all the components which will be included in the three types of cubicles, including the ordinary components mentioned in sub-section 5.4.1. The BOM shall be a free-form document agreed with the IO TRO.
- The detailed functional specifications related to the integration of the SCUs/regulators mentioned in sub-section 5.4.1. These specifications shall be discussed with and eventually agreed by the IO TRO and shall include the configuration of the devices, the functions to communicate with the controller, the management of the faults and of the recoveries and, in particular for each device:
    - Inficon: The reading of a Pirani TPR018 pressure sensor. The sensor and the cable for the connection to the SCU shall be supplied by IO.
      The Contractor shall use the Ethernet port as main interface with the TPG500 for SCU configuration. The Contractor shall use ad-hoc routines and HMI developed by IO to interface the device with the CODAC environment, which is based on the EPICS framework (https://epics-controls.org/) via the PSH. This will interface the SCU directly to the PSH, without the need to go through the PLC.
      The Contractor shall also use the Profibus DP interface to exchange data between the TPG500 and the PLC.
    - Gantner: The reading of a temperature measurement simulated by a potentiometer. The Contractor shall procure the potentiometer. Any other means to simulate the temperature reading shall be agreed with the IO TRO.
    - Cryomagnetics: The integration of the SCU within the control system. The Contractor should be able to set up the system in order to test the reading of a signal without having to use a real sensor.
      An external Ethernet interface is also needed for device configuration. It is possible to set up locally the SCU by using its display, however the Contractor might be requested to develop ad-hoc routines (and HMI), using the commands available on the SCU manual, to interface the device with the EPICS-based CODAC environment via the PSH. The HMI should be based on BOY.
    - Opsens: The reading of a simulated pressure sensor (supplied by IO) via the CSC-M Ethernet interface and via the Coresens analogue output.

      N.B.:

        - The preferred architecture for ITER is to consider all the CoreSens SCU as slaves of the PSH, with which they are connected via the PON network (Ethernet) through the CSC-M communication module. IO shall provide the custom routines and HMI to interface the SCU with the PSH and the EPICS environment.
        - The Coresens chassis also has analogue outputs (0-10V) that can be used to acquire the data via a remote I/O. The Contractor shall also implement this solution for all the theoretical signals, to be used just in case of loss of communication.
    - Hiden Analytical: The Contractor shall consider the RC control unit Ethernet interface as the main interface. The Contractor shall use the custom routines and HMI provided by IO to interface the RC control unit with the PSH and the

EPICS environment. The RF unit shall only be used for space and cable verification.

For redundancy purposes, the Contractor shall connect the RC control unit digital I/O port MSC04 to the PLC via the ad-hoc cable in order to get the physical I/O from the RC unit, but the main interface will remain the Ethernet one. This port offers eight inputs and eight open-collector outputs compatible with 24 VDC. In order to replicate the plant environment, the RGA measurements can be simulated through the custom HMI provided by IO.

The RC control unit is also equipped with a TRIPS port MSC11 to be used to protect the RGA from overpressure. For maximum protection, it is recommended that an external pressure gauge, such a cold cathode gauge (like one of those connected to the Inficon TPG500), is linked to this interface. The Contractor shall investigate of a solution to interlock the RGA with a cold-cathode measurement, even if the preferred solution is to control the interlock through an output of the ET 200SP Relay Module #2 mentioned in Table 3.

- Osaka Vacuum: the set-up of the communication with the Turbo Controller unit TC010MA-31 using the RS-232 communication. It shall be possible to avoid using the TMP, but in this case the available functionalities shall be reduced. The Repeater unit RBR-1-150 shall only be considered for space reservation and involved in the tests only if really necessary. The Contractor shall discuss this part with the IO TRO.
- TDK Lambda: The set-up of a small test bench involving a heating element and a PT100. The test bench is described at the end of this chapter. The Contractor shall use this test bench to regulate the power on the heating element in order to attain a specific temperature. Both kinds of TDK Lambda power regulators shall be tested. Both of them are installed in the 6101 cubicle.
- Cryogenic Velan valve control: Before adopting the aforementioned SIPART PS2 solution with the Hoerbiger pilot valve, the Contractor shall envisage an alternative way using, if possible, standard Siemens cards. The Contractor shall also evaluate a pilot valve alternative to the Hoerbiger one, provided that it can fulfil the same purpose. For instance, the Contractor could see if a valve from Burkert (not the same mentioned above) could make the job. IO shall provide the requirements, the actuator (the Velan valve or a similar one) and a Hoerbiger pilot valve. The Contractor shall procure the remaining elements, in agreement with the IO TRO. If the Contractor demonstrates that an alternative solution is not feasible, IO shall provide the Contractor with the Siemens SIPART PS2 drawer and a 5-channel QRL module. The Contractor shall procure the remaining equipment, like the Siemens Profibus DP/PA module and the cables.

  It is reminded that the main purpose of this task is to integrate the control of the proportional valve within the PSCC.
- Burkert: The set-up of a small test bench involving a Burkert valve, a small gas tank and a basic pressure sensor. The Contractor shall use this test bench to control the opening/closing of the Burkert valve via the Siemens PWM module. The test bench is described at the end of this chapter.
- Rough heater control: Using the same test bench as the TDK Lambda one, the Contractor shall test the rough control of a heater by using the Siemens phase-control module.
- Isolation valves: The simulation of the behaviour of an isolation valve involving the actuation of a pneumatic pilot valve via a DO and the reading of two position indicators.

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- The remote switch-on/switch -off of the active components using the Siemens relay module.
- The network architecture of the three cubicles and of the inner components (including the CMS), as a free-form electronic document. The file format shall be agreed with the IO TRO. In order to reproduce the same conditions as in Figure 12 of [I04] (with the only difference that the fibre-optics will not be redundant):
  - The 6101 devices shall be connected to the network switch in the 6001 cubicle via conventional copper Ethernet (CAT5) cables.
  - The 6104 devices shall be connected to another Hirschmann MACH102 network switch in the same cubicle. Then this network switch shall be connected via fibre-optics to the network switch in the 6001 cubicle. The fibre-optics will be single-mode fibres, LC-LC duplex patch cord, OS2 9/125 µm (ITU-T G.652.D) [I43].

  The Contractor shall provide the Ethernet cables and the fibre-optics.
- A free-form document, agreed with the IO TRO, showing the power loads and the heat losses per component and for the overall cubicles. The overall cubicle heat losses shall be compared with the heat dissipation capabilities of the cubicle (which are normally up to 2 kW). Engineering tools will be used to support the heat loss analysis.
- The cubicle wiring diagram, which will include three additional pages showing the cubicle layout (front, rear and side). The wiring diagram shall be produced using See Electrical Expert.

All the documents shall be provided in the form of a .zip file.

N.B.:

- The Contractor should spare some space in the cubicles in case it will be needed to shield the some of the hardware components in order to be compliant with the constraints related to the tokamak static magnetic field (SMF) and with the electro-magnetic compatibility, as described in chapters 6 and 7 of [I28]. The Contractor shall strictly work with IO in order to take in consideration the constraints, where needed.
- This deliverable shall be considered achieved when all the due documents are approved in IDM.

12.2 L2-D2: Cubicle Prototype Manufacturing

The Contractor shall procure all the identified missing components and manufacture the cubicle prototypes. The list of the component to be purchased will have to be agreed by the IO TRO. The Contractor shall provide the IO TRO with the equipment delivery note.

A plan for the continuity test shall also be provided, including grounding tests.

Before starting the cubicle manufacturing, the Contractor shall organise a simplified MRR according to [AD4]. Approval of the MRR report by the IO TRO shall be the criterion to start the cubicle manufacturing.

This deliverable shall be considered achieved upon:

- Acceptance by the IO TRO of the delivery note, which shall be in line with the financial offer (see Section 10.5).
- Acceptance of the cubicle prototype manufacturing by the IO TRO
- Positive outcome of the continuity tests, captured in a continuity test report.

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It shall be care of the Contractor to assemble components and cables in the cubicles aiming at an optimal cables and components layout, so as to improving quality and easing cubicle maintenance.

It is reminded that a network interface with the Mini-CODAC tool will have to be taken into account.

It shall be duty of the Contractor to anticipate the procurement of the missing components, so as not to delay the cubicle prototype manufacturing.

12.3 L2-D3: Cubicle Prototype Software Specifications

In compliance with [I19], [I40], [I41], the Contractor shall provide the software specifications of the three cubicle prototypes, including:

- The software architecture.
- Procedures for installations of hardware and software packages, if any.
- The Mini-CODAC tool configuration, as required for the integration and tests of the cubicle prototype, if relevant.
- SCUs and regulators configuration files and/or documents, if relevant.

The software specification shall be produced as a free-form document agreed with the IO TRO.

All the documents shall be provided in the form of a .zip file.

12.4 L2-D4: Cubicle Prototype Software Programming

Upon IO acceptance of L2-D3 and based on the L2-D1 and L2-D3 specifications, the Contractor shall:

- Program the Siemens controller and configure the SCUs and the regulators.
- Upload the Siemens source code in svnpub using a naming convention agreed with IO. The link to the source code in svnpub shall be provided to IO.
- Provide the Self-Description Data (SDD) as per [I42].

12.5 L2-D5: Cubicle Prototype Integration

The Contractor shall integrate the cubicle prototype into the CODAC environment using the Mini-CODAC tool. The Contractor shall also test the integration of the SCUs and of the regulators by:

- Following the technical specification in the scope of deliverable L2-D1.
- Producing cubicle prototype test plans and cubicle prototype test reports.
- The integration shall include the development of user software, i.e. of an HMI with BOY, to support the test results. The source code of the HMI shall be uploaded in svnpub. The link to the source code in svnpub shall be provided to IO.

All the documents shall be provided in the form of a .zip file.

This deliverable shall be considered achieved upon acceptance of the test reports by the IO TRO.

12.6 Test Bench for Cryogenic Systems Integration

The Contractor shall provide a massive copper block with a mass of about 1-1.5 kg. The copper block shall include two cylindrical holes for the following cartridge heaters:

- VULSTAR 10163.12 (6.5x40 mm, max 125 W each).

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The block shall include seats for two PT100 or two CERNOX sensors, screwed on a flat surface, e.g.:

- PT100: Lakeshore PT-102-AL or PT-103-AM.
- CERNOX: LakeShore CX-1070 (low sensitivity at and above room temperature).

The copper block shall be ideally insulated from the room and cooled down by a cooling fan or by a water channel loop, with regulated flow. The test bench shall be used to regulate the power on the heaters in order to attain a specific temperature above room temperature both with TDK Lambda power regulators and with the Siemens phase-control-based system.

12.7 Test Bench for Burkert Control Integration

The Bürkert control valve, supplied by IO, should be connected to a compressed air supply on the inlet side and a flow meter at the outlets to observe the flow. The compressed air should not exceed a pressure of 8 bara and should be oil-free. The flow meter should be able to cover the expected flow rates between 0 and 40 l/min. The flow meter shall be procured by the Contractor. IO shall provide, during the contract execution, the additional requirements related to the operation of the Burkert valve.

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13 Appendix 3 – Lot-3 Deliverables – Optional

13.1 L3-D1: Process Simulation Framework

The Contractor shall spend the first period by studying the DMS process documents and by collecting the data necessary to model the process and implement the PSCC functions. During this time, frequent exchanges with the IO process engineers and with the TRO will be necessary to establish the correct framework for the process simulation, based also on the Contractor's experience in terms of simulations. At the end of the period, the Contractor shall supply a report describing the simulation framework, all the interface data necessary to simulate the process (configuration parameters, interface with other plant systems, physic value necessary to initialize the process, etc.), all the equations and any other information deemed relevant by the Contractor to establish the simulation framework. The format of the report shall be agreed together with the IO TRO. Within this deliverable, the Contractor shall also provide the software delivery note. Acceptance of this delivery note by the IO TRO shall be part of the acceptance of this deliverable.

13.2 L3-D2: Simulator Software Specifications

In compliance with [I40] and [I41], the Contractor shall provide the software specifications of the simulation tool, including:

- The software architecture.
- Procedures for installations of hardware and software packages, if any.
- Configuration files and/or documents, if relevant.

The software specification shall be produced as a free-form document agreed with the IO TRO.

All the documents shall be provided in the form of a .zip file.

13.3 L3-D3: Bank Simulation

Upon IO acceptance of L3-D2, the Contractor shall program SIMIT and PLCSIM Advanced in order to reproduce the behaviour and control of one injector and of the associated cryogenic and non-cryogenic systems. The software shall be programmed in such a way that it can be easily extended to six injectors, including the common cryogenic and non-cryogenic part. Object programming and modularity are essential drivers.

Ideally, the PLCSIM Advanced program should be such that it can reuse the libraries developed under the Lot-2 deliverables to read/write the I/O.

In the end, the Contractor shall:

- Program PLCSIM Advanced and SIMIT.
- Upload the source code in svnpub using a naming convention agreed with IO. The link to the source code in svnpub shall be provided to IO.
- Provide the SDD as per [I42].
- Identify some use cases, in agreement with IO, to be used as test plan and produce such test plan.
- Produce a test report.

This deliverable shall be considered achieved upon acceptance of the test reports by the IO TRO.