CODAC Services Development and Maintenance

Call for Nomination

1 Purpose

The purpose of this contract is to provide the technical services required for the design, development, maintenance and integration of ITER CODAC Services. All services rendered by the Contractor are within the scope of CODAC functions - Control, Data Access, and Communication (PBS 45) functions:

a) *"Networking to communicate information between all plant systems and CODAC*
b) *Monitoring the ITER plant and displaying the status to operator stations*
c) *Acquiring, archiving and providing access to all engineering and scientific data concerning the operation of ITER for the duration of the project and beyond*
d) *Methods for specifying and verifying the parameters used during ITER operation, including during plasma pulses both on-site and remotely*
e) *Providing, distributing and monitoring a project-wide time reference*
f) *Providing, distributing and recording audio and video information inside the plant*
g) *Operating ITER in terms of Global Operating States, which are linked to the Operation Limits and Conditions*
h) *The infrastructure for controlling plasmas and other pulse-related activities*
i) *The infrastructure for providing all calculations needed for ITER operation, including verification before and during plasma pulses and diagnostic data evaluation during plasma pulses*
j) *Features allowing ITER to be efficiently exploited from remote sites*
k) *Equipment allowing to be operated independently, for commissioning, testing and maintenance*
l) *Features allowing the collaborative research activity to be efficiently executed given the distributed nature of the research teams*
m) *Operator terminals allowing the operation of the ITER plant at the engineering level of each plant, and at the operation level of the integrated plant*
n) *Managing Instrumentation and Control (I&C) for all ITER systems."*

This Contract is a framework contract, where each task order (TO) is a free standing engineering activity with its own budget.

2 Background

2.1 System Architecture

Figure 2-1 illustrates the physical architecture of the complete ITER I&C system. A plant system I&C is a unit which interfaces to CODAC and which includes a set of tightly coupled controllers, with one and only one, PSH implementing a set of plant-specific and generic (common) functions. A control group is an assembly of plant system I&Cs and central coordination – CRYO, MAGNET, WATER COOLING SYSTEM...

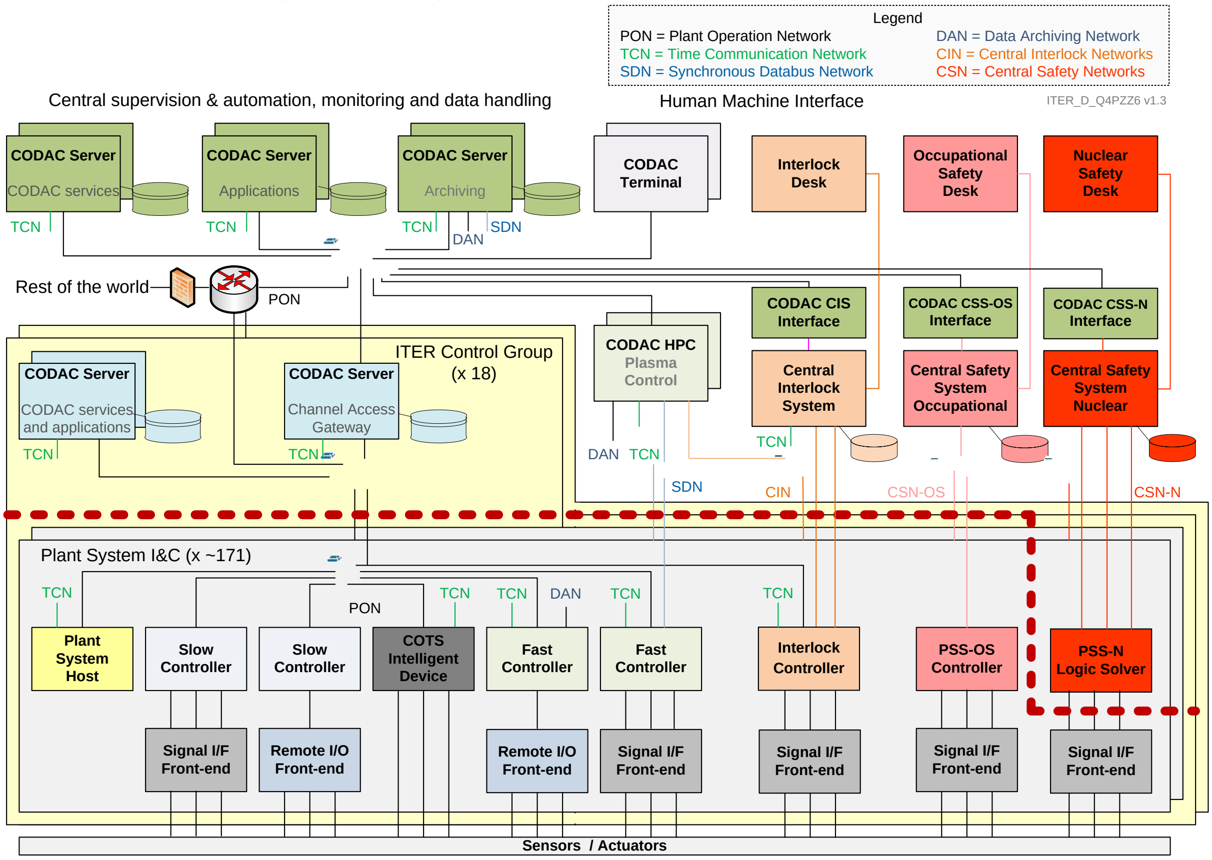

Figure 2-1 Physical architecture of CODAC

Figure 2-2 shows the scope of CODAC based on CODAC services and applications.

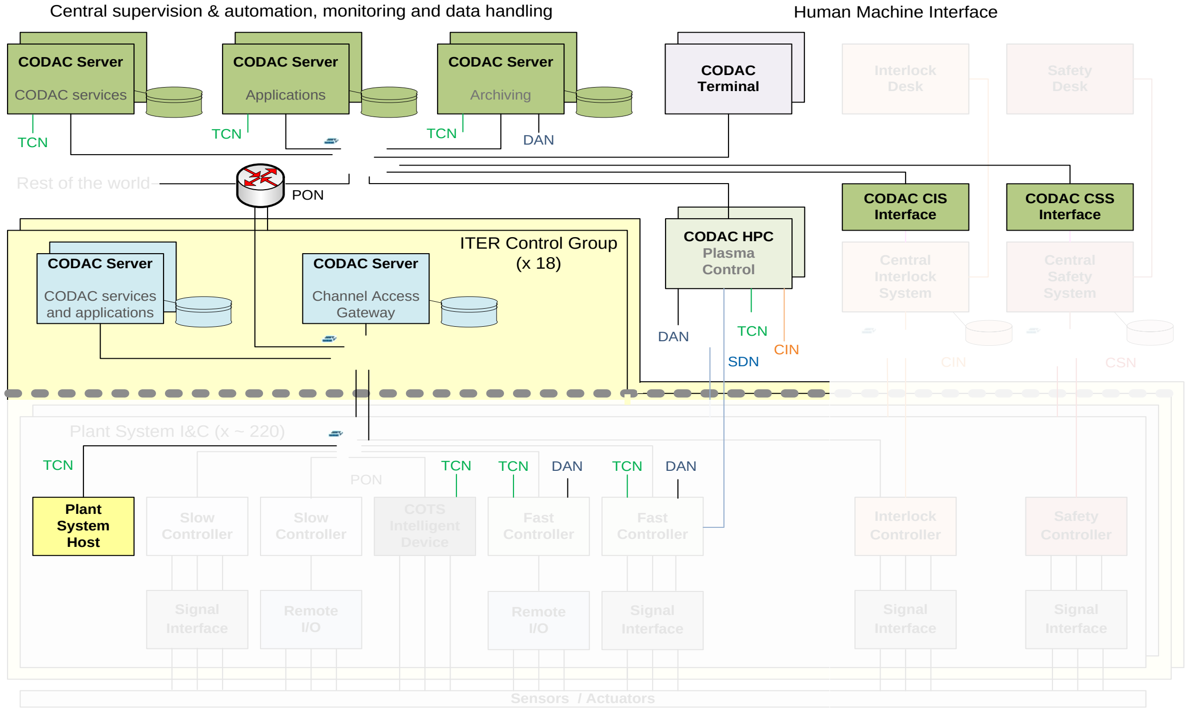

Figure 2-2 Scope of CODAC and external interfaces

2.2 Software Infrastructure

CODAC runtime software is divided into three layers: the Operating System, the CODAC Core System infrastructure layer and CODAC services and operation applications.
The CODAC Core System includes both the infrastructure layer and services. It provides common services and is deployed on all CODAC computers as well as on plant system hosts and fast controllers within the plant system I&Cs.
Common services run on top of the CODAC Core System infrastructure layer.
To mitigate the risk of obsolescence, the CODAC Core System will have major releases and several minor maintenance releases throughout the lifetime of ITER.
This runtime software architecture is illustrated in Figure 2-3.

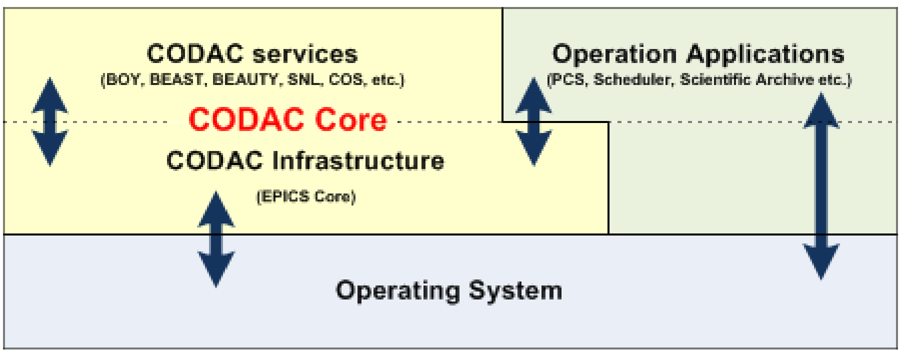

Figure 2-3 Runtime Software Architecture

2.2.1 Operating System

The Operating System is Red Hat Enterprise Linux (RHEL). As with the CODAC Core System, the operating system's risk of obsolescence is mitigated by upgrading it with minor maintenance releases synchronised with the CODAC Core System releases; they are bundled together so that a known CODAC Core System version is always installed together with a defined RHEL version. For computers running fast feedback control (CODAC HPC and plant system fast controllers) a real-time enabled version of RHEL, called RHEL with MRG-R kernel option, is deployed.

2.2.2 EPICS

The complete control architecture is implemented as a soft real-time distributed control system based on the EPICS (Experimental Physics and Industrial Control System) architecture and software with standard EPICS-compliant hardware ranging from IPCs to PLCs.

With a two-tier approach, the backbone of the control network infrastructure relies on a fast, specialised and very robust Ethernet-based software bus called Channel Access (CA) which also ensures a uniform interface between the CODAC central control system and the local control systems.

The real-time EPICS Process Variable (PV) database is distributed in a scalable way over many Channel Access Servers (CAS) which are in charge of providing data to the Channel Access Clients (CAC). Thus the software architecture is a typical client-server model, backed up with a publish/subscribe messaging paradigm throughout the control network. The requests are based on the PV name and include Search, Get, Put and Add Event (add monitor - "monitors" send data to the client only when it has changed).

A PV has real-time attributes including value, time, alarm status and severity, and configuration attributes such as units, precision, conversion parameters, graphic limits, control limits and alarm limits.

A PV is a typed structure according to a record type – Binary Input, Binary Output, Analog Input, Analog Output, Calculation, PID… - and the inputs, data manipulation, and outputs are defined by configuring each record. It is the fundamental responsibility of the EPICS Input/Output Controller (IOC) to input data from the local process (and/or the operator), manipulate/convert/compute it in a predefined manner, update the PV value timestamp and alarm status/severity and optionally output data to control the local process.

EPICS PVs become part of an IOC's database. The IOC scans the database, deciding when to and knowing how to process a predefined record.

Records can also be linked together to create control algorithms and sequences.

Finally, input and output records have a specific field, DTYP, to specify the device type (I/O board, PLC) and the INP and OUT fields to specify additional parameters, for example the board and channel number or the PV position within the PLC data block.

2.3 Hardware Components

This section explains the characteristics of the main hardware components used in CODAC Systems.

2.3.1 CODAC Server

A central CODAC server is a standard server-class computer running either CODAC run-time applications or CODAC support services. Run-time server applications include common

EPICS applications such as archiving and alarm handling and common site-specific applications, including plant wide supervision, monitoring and control, global operational state management and interfaces to the CIS and CSS. In addition, CODAC servers run special applications such as pulse scheduling and scientific data archiving. CODAC support services include directory services, software download to plant systems and software configuration management. CODAC servers are installed in the CODAC server room in the control building (B71) with some backup servers located in Building 24.
As a temporary stage, CODAC servers will be installed in Temporary Control Rooms (TCR) located in different buildings and CODAC services will be configured locally in each TCR and then synchronized/merged regularly with the central CODAC infrastructure.

2.3.2 CODAC Terminal

A CODAC terminal is an operation station providing input and output to/from an operator through the human-machine interface (HMI). CODAC terminals are primarily installed in the ITER control rooms – including TCRs, however, portable CODAC terminals may also be temporarily installed (using a network connection) close to local plant system equipment for integration, commissioning, troubleshooting and maintenance of that equipment. Control Room CODAC terminals and portable CODAC terminals use identical runtime software, deployed and configured using the CODAC Core System.

2.3.2.1 HMI Definition

Definitions as represented on Figure 2-4 include:

- VDU workstation or "station" composed of at least 3 VDUs or "monitor" 16/9 with a resolution of 3840 x 2160 - diagonally viewable size of 24 inches
- Full screen display canvas with a navigation pane, status bar, alarm and control pane
- A mimic embedded within the display canvas

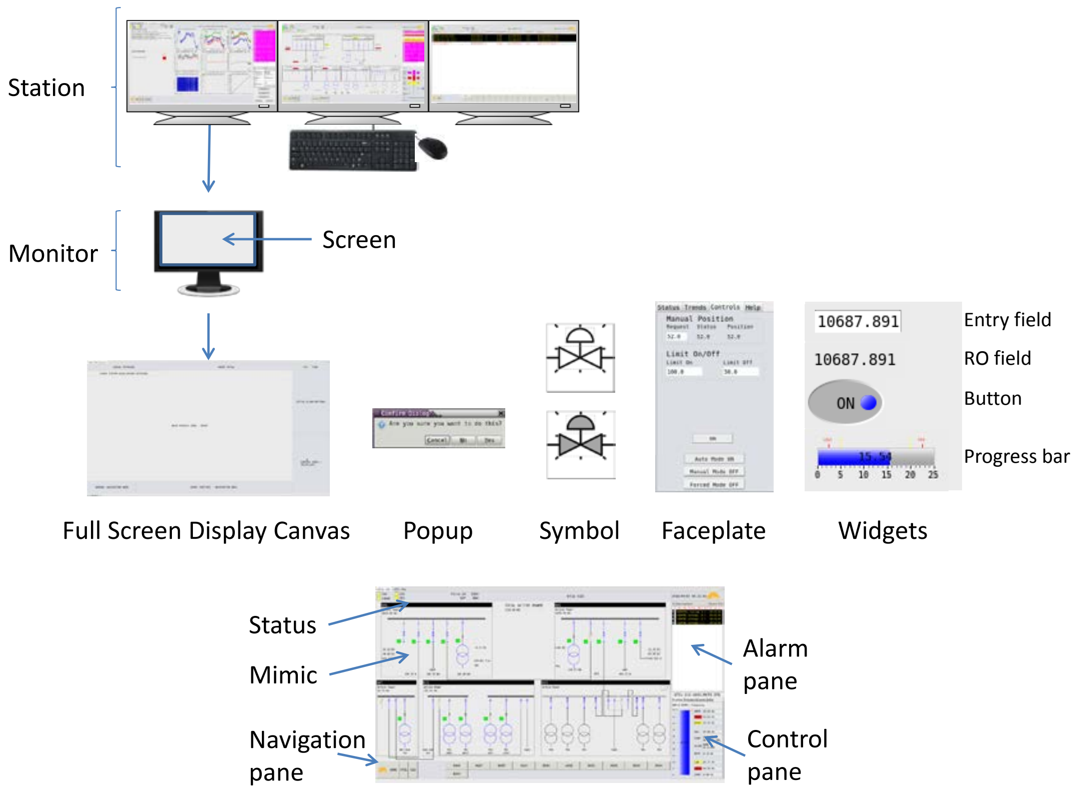

Figure 2-4 HMI basic definitions

2.3.2.2 ***HMI Style Guide***

HMI Style Guide includes general design principles for the displays derived from Operation and Human Factors requirements. It describes the displays layout and organisation.

2.3.2.3 ***HMI Toolkit***

An HMI toolkit is delivered with CODAC Core System to edit and run displays used to control and monitor systems on the ITER site during and throughout commissioning, operation and maintenance phases. The toolkit is based on CS-Studio (CSS) set of tools that includes an operator interface (BOY), an alarm system (BEAST) and an archive system (BEAUTY).

The HMI toolkit provides standardised colours and fonts, a collection of graphical objects – widgets – that the user can drag and drop from the palette to the display canvas, trend widgets, an industrial symbol library (electrical breaker, valve, pump…) and many templates.

2.3.3 Plant Operation Network (PON)

The Plant Operation Network (PON) is a general purpose TCP/IP communication network connecting all hosts of the ITER I&C system. The PON provides asynchronous transport of commands and data. It carries internal plant system control, monitoring and supervision traffic as well as traffic between plant system I&Cs and CODAC.
Based on the EPICS framework's ability to find services by broadcasting, PON establishes the communication between data producers (CA servers) and data consumers (CA clients). CODAC Services are mainly Channel Access Clients which subscribe to process variable and monitor changes to take actions – actions being animating a graphical widget on a display, archiving a new value in the PON archiving storage or creating an electronic logbook entry in case of alarm.

3 Scope of Work

CODAC Services rely on open source solutions for software development, integration and maintenance activities. These are the groups of software covered by the framework:

- Operating system (Linux Red Hat), access control (OpenLDAP)
- Databases (PostgreSQL, NoSQL)
- Middleware: message busses/queues (JMS Apache ActiveMQ), web servers (Apache Tomcat), SOA (Service-Oriented Architecture), REST services
- Development tools: Integrated Development Environments (IDEs) (JAVA Eclipse with the support of Python and JavaScript), compilers, test tools, version management (GIT and SVN), build system (Tycho, Maven, Jenkins), package management (RPM), QA tools (Sonar, Check Style, PMD, FindBugs and EclEmma plugins)
- Statistics software: data warehousing (Elasticsearch, InfluxDB), data mining, data visualization (Kibana, Chronograf), spreadsheet tools, report generators, web statistics (Logstash, Kapacitor)
- Operational support: backup, deployment, monitoring, bugtracker (Bugzilla, Jira)
- Office support: collaboration, communication, project management

Based on open source solutions, CODAC Services provide to ITER users complex applications developed by a community of different laboratories and universities in which IO is a key player and contributor.

The main applications are:

- Operator Interface (OPI) – BOY - that connects to the control system, animates graphical widgets according to EPICS process Variable (PV) value, alarm status/severity and connection/RW status, shows PV's range and alarm limits definition and allows the operator to interact with the process by providing input data and sending commands,
- Alarm System – BEAST - that monitors alarm triggers in the control system and provides essential support to the operator by warning him of situations that need his attention, showing guidance, allowing him to open dedicated alarm pages, execute commands and acknowledge raised alarms,
- PON Archive System – BEAUTY - that monitors archived EPICS PVs in the control system and provides a graphical user interface for displaying live and historic data in a plot, making some computation, adding annotations and exporting samples into different file formats such as Excel spread sheet or Matlab,
- Electronic Logbook – OLOG - that registers events entered manually or generated automatically during operation to keep track of problems, human decisions or actions which were taken during the course of the activity and which may have had an impact on the outcome of the activity,
- Diagnostic tools to inspect EPICS PVs and display them in a tabular view, snoop CA network traffic, monitor JAVA memory usage,
- Sequence of EPICS commands automation and support of State Notation Language (SNL),
- Reporting and monitoring tools – to assess the Alarm System by charting the alarms per day or in 10 min intervals and displaying the "top 10" alarms for a given time period; to assess the number of archived samples over a given period and the number of overruns as it draws attention to possible data loss.

CODAC Services within a highly modular and distributed architecture are designed for responsiveness to ITER project requirements and changes.

They are configurable, have a well-defined interface and can adapt to ITER site technical platform (operating system, database, time format…).

Most of CODAC Services have a high level of maturity and require a high level of expertise – based on EPICS which is fairly stable, the alarm and archive systems are not changing rapidly even though the concept of alarms for operation has been challenged by ITER requirements, and new data store technologies have to be considered. The operator interface and its underlying components on the other hand may require a continuous cycle of incremental improvement and modernisation in order to fulfil ITER Human Factors requirements.

CODAC Services size, scope and complexity are important – many services to address many different problems. But the development and maintenance effort is shared among the community of developers.

Finally, CODAC Services will be used 24h/24h 7d/7 and will contribute to CODAC system availability of 98.8%.

This summary covers the technical services to be provided to IO along the development and maintenance life cycle of CODAC Services. These services cover the following topics:

1. **Design of "application" service:** Capture the user and technical requirements for the CODAC application service, specify the service operation and API/interface, and define the behaviours and rules that the service must provide. Develop, test and document the CODAC application service following the community and ITER best practices.

   These services will be provided as needed by the project.

   Services are expected to be provided either on or off-site. Precise location will be defined at the Task order level.

2. **Design of "core" service:** Capture the common component requirements for the core service, wrap and extend the underlying 3^{rd} party platform and framework that are provided as part of the configuration so that these can be changed with minimal impact on the community of developers, isolate those elements of the service that the user is most likely to enhance or extend to reflect more specific project requirements. Develop, test and document the core service following the community and ITER best practices.

   These services will be provided as needed by the project.

   Services are expected to be provided either on or off-site. Precise location will be defined at the Task order level.

3. **Maintenance:** Integrate continuous updates and upgrades from the community such as CS-Studio monthly releases. Customise the services to ITER environment. Adapt the services to new major or minor versions of underlying components. Provide data and software migration to a new platform procedure. Provide build, packaging, configuration and backup procedures and scripts. Detect, support, analyse and fix bugs. Prevent problems by refactoring the services to make them more robust, flexible and extensible.

   Services are expected to be provided either on or off-site. Precise location will be defined at the Task order level.

4. **Release preparation:** Prepare, build, test, document, coordinate and deliver major, minor, patch or snapshot release for ITER users according to requirements and plan. Audit the quality. Benchmark the performances. Produce test reports. Produce the release notes.

   These services will be provided as needed by the project.

   Services are expected to be provided either on or off-site. Precise location will be defined at the Task order level.

5. **CODAC services technical support:** Support CODAC services users, develop templates and standard resources, prepare integration procedures and tools, procure CODAC operator interface according to requirements and plan.

   These services will be provided as needed by the project.

   Services are expected to be provided either on or off-site. Precise location will be defined at the Task order level.

As a general statement, the details of the services to be provided by the Contractor will be defined in the task order technical specification documents.

These technical specifications shall be defined specifically according to CODAC Services roadmap and shall include a technical scope and a description of the deliverables.

4 Duration of Services

The contract will be carried out over an initial firm period of three (3) years firm and an optional period of one (1) year. The contract is scheduled to come into force in April 2018.

5 Revised Timetable

The tentative timetable is as follows:

Launch of Call for Nomination	September 2017
Launch of Prequalification	October 2017
Launch of Call for Tender	December 2018
Signature	March 2018

6 Experience

The contractor and its personnel shall have adequate experience in the development of highly modular and distributed architecture designed for responsiveness to ITER project requirements and changes. This includes but is not comprehensive:

- Ability to work in collaboration with laboratories and universities on open source solutions
- Development and maintenance of supervisory control and data acquisition application and core services
- Software release management
- User back office technical support
- Technical skills in the software platform as described in section 3.

7 Candidature

Participation is open to all legal persons participating either individually or in a grouping (consortium) which is established in an ITER Member State. A legal person cannot participate individually or as a consortium partner in more than one application or tender. A consortium may be a permanent, legally-established grouping or a grouping, which has been constituted informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.

The consortium groupings shall be presented at the pre-qualification stage. The tenderer's composition cannot be modified without the approval of the ITER Organization after the pre-qualification.

Legal entities belonging to the same legal grouping are allowed to participate separately if they are able to demonstrate independent technical and financial capacities. Candidates (individual or consortium) must comply with the selection criteria. The IO reserves the right to disregard duplicated reference projects and may exclude such legal entities from the pre-qualification procedure.

8 Reference

Further information on the ITER Organization procurement can be found at: http://www.iter.org/org/team/adm/proc/overview