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EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

CFE - NI cRIO replacement evaluation support

Call for Expertise - Technical specification and statement of work to be performed related to evaluation of NI cRIO replacement as part of the management of the obsolescence of ITER standard control system platform.

Table of contents

1 PURPOSE

This document provides the technical specification and statement of work for activities to be performed under a Call for Expertise (CfE) to support the execution of the obsolescence management plan of ITER standard control system component.

2 BACKGROUND

The ITER project has produced a Plant Control Design Handbook (PCDH) including mandatory functional and non-functional requirements for Plant Instrumentation and Control (I&C) systems. Plant I&C design teams are encouraged to select hardware and software components from a standard catalogue maintained by the ITER project.

The ITER Standard Catalogue for I&C products includes the use of the NI-9159 cRIO chassis for implementation of Fast Control I&C and Machine Prtection solutions.

The NI-9159 cRIO chassis provides hardened Input/Output (I/O) expansion capabilities for Fast Controllers or Data Acquisition platforms and is compatible with the environmental conditions as exist in the Tokamak complex.

The NI-9159 cRIO chassis is integrated with industrial computers using PCIe over optical fiber interconnect for which an open-source Linux driver is available and maintained by the ITER Organization.

The NI-9159 cRIO chassis will reach End of Life (EoL) status in Q4-2023 and National Instruments (NI) is discontinuing MXI interconnects for cRIO chassis. From that date onwards, the cRIO product family will be exclusively based to copper Ethernet interconnects, i.e. EtherCAT chassis or Ethernet interfacing embedded Real-Time controllers.

The NI-9159 obsolescence management plan follows three axes, see **Error! Reference source not found.**:

- Communication to Plant I&C design teams through an update of the ITER standard catalogue,
- Provision of necessary spare parts for First Plasma I&C systems for 10 years operation,
- Identification and evaluation of replacement solutions.

3 SCOPE

The Call For Expertise (CfE) aims at securing access to additional relevant technical competences to support the identification and evaluation of replacement for the NI-9159 component.

4 DEFINITIONS

CfE	Call for Expertise
CODAC	Control, Data Access and Communications

cRIO	Compact Reconfigurable Input/Output
EMC	Electro-Magnetic Compatibility
EPICS	Experimental Physics and Industrial Control System
I&C	Instrumentation and Control
NI	National Instruments
PCDH	Plant Control Design Handbook
PCIe	Peripheral Component Interconnect Express
SMF	Static Magnetic Field
SMS	System Manufacturing Specification
STR	System Test Report
STP	System Test Plan

5 REFERENCES

[RD1] SEQA-45 - Software Engineering and Quality Assurance for CODAC (2NRS2K)

[RD2] ITER Catalog of I&C products - Fast Controllers v2.7 (345X28)

[RD3] NI-RIO Device Driver User Manual (LW3UFH)

[RD4] Obsolesence management plan - NI-9159 cRIO chassis (6JG7Q5)

6 ESTIMATED DURATION

The contract duration is maximum 12 months.

7 WORK DESCRIPTION

ITER Organization and NI already identified a potential candidate amongst the NI product catalogue to be evaluated and is also seeking an independent survey and advice for a potential alternative architecture/platform/technology.

7.1 NI recommended platform evaluation

NI has proposed NI-9049 cRIO Controller as candidate for NI-9159 substitution. This solution implies a change in the architecture of the platform, now including an embedded Intel Atom controller, and a change in the interface, including Ethernet instead of MXIe interface. The evaluation of the platform is divided in the following tasks:

Preliminary study of the NI recommended platform evaluation:

- Study of given platform solution, interfaces, and development cycle
- Proposal of architecture and workflow for migration from existing solution

Formulation of a System Test Plan (STP) covering the verification of the following aspects:

- Assessment of function, communication latency and throughput between FPGA and industrial computer
- Reliability and robustness assessment under representative EM and SMF loads

Design and implementation of a RT/FPGA template application, corresponding Linux driver, and use case example offering a smooth migration path from existing solution including the following features:

- Interface introspection from compiled bitfile
- Read/write access to named indicators/controls
- Read/write access to FIFO queues
- Interface with CODAC Core System

Execution of system test plan on ITER premises and elaboration of the System Test Plan Report, incl. delivery of the necessary software sources and applications to be used during the EM and SMF tests.

Formulation of evaluation activities final report and update of the already delivered documentation if required.

The task will be completed upon delivery and approval of the following elements:

- Architecture design of migration solution
- Software sources
- LabVIEW template and use case sources
- System Test Plan
- System Test Report
- Final report of platform evaluation activities

7.2 Alternative technology proposal formulation

This activity consist on performing a market and/or technological study and propose a long-term alternative for the use of NI-9159 on Control and Data Acquisition systems. The proposal should address ideally the following needs:

- Modular architecture
- FPGA-based platform
- Open source hardware interface
- Ideally open-hardware and open-software stack
- Plausible maintainability for 30 years or plausible migration path
- Capability to interface with standard ITER Fast controller Interfaces, preferably PCIe over optical fiber.

The activity scope is the formulation of a technical proposal, work plan, and preliminary resource estimate for a subsequent verification of the technical proposal. The deliverable of this activity should also include the results of the market survey, including documented trade off analysis and identification of risks for the alternatives proposed.

7.3 Deliverable breakdown

Table 1 presents the deliverable breakdown with estimated task duration in weeks and expected delivery date. The delivery dates correspond to the schedule proposed on Figure 1.

Alternatively, the plan for the execution of the activities under the CfE may opt to swap the two tasks or consider an interleaved approach.

Table 1 Deliverable breakdown

Title	Outputs/Features	Weeks	Date
1.1 Preliminary platform study	Architecture and workflow proposal for migration from NI-9159 to NI-9049 Evaluation of incompatibilities	8	03/03/23
1.2 System test plan	System Test plan	8	28/04/23
1.3 Use case design and implementation	LabVIEW template and use case sources Software sources	16	14/07/23
1.4 System test plan execution	System Test Report	2	28/07/23
	Update on Deliverables 1.1 to 1.4 (if needed)		
1.5 Final delivery	Final report	4	29/09/23
2.1 Initial market survey	Market survey report	4	27/10/23
2.2 Technical proposal	Preliminary Technical Proposal	8	23/12/23

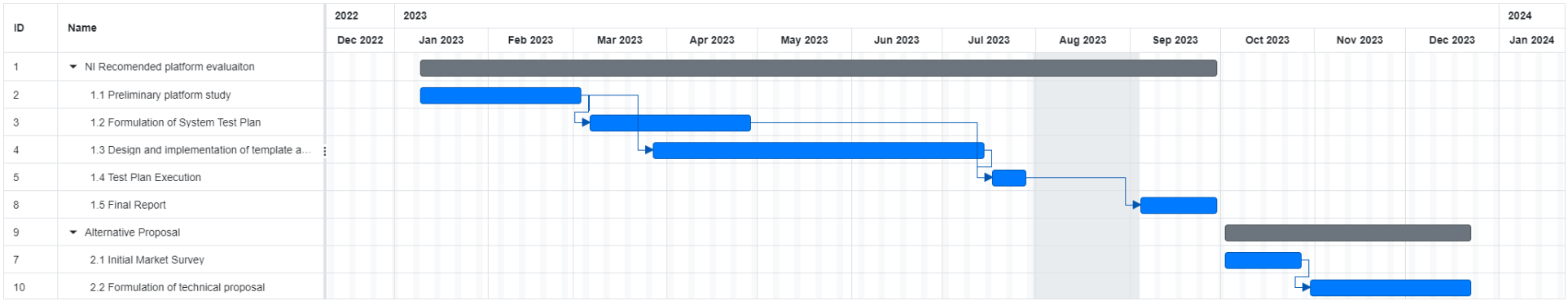

Figure 1 Proposed task schedule

8 RESPONSIBILITIES

8.1 ITER Organization

IO will nominate a Technical Responsible Officer for this contract.

IO will provide the necessary hardware and software resources for the implementation of activities covered in 7.1. In particular, IO will provide access to SMF test facility on ITER site.

8.2 Contractor

The contractor will provide specialist resources on a long-term permanent basis for the duration and at the location required under this scope of work. The contractor undertakes that:

- The personnel will possess the qualifications, professional competence and experience to carry out such services in accordance with best practice within the industry;
- The personnel will be bound by the rules and regulations governing ITER safety and security when present at ITER premises;
- The required safety clearance deliverables will be provided and maintained accurate during period of execution of the services.

9 EXPERIENCE AND SPECIFIC SKILLS

Education:

- Master degree or equivalent in Electronics, Control Engineering or Computer Science.

Professional experience:

- At least 10 years' experience working as Control Software Engineer in designing, installing, commissioning or operation of large-scale scientific control systems;
- Familiarity with fusion machines, plasma physics and tokamak diagnostics is considered most advantageous.

Technical Competencies and demonstrated experience in:

- Using, designing, implementing and verifying control system distributed software frameworks and applications;
- Executing software integration and verification of heterogeneous I&C systems, including identifying and resolving issues;
- Using Linux, real-time operating systems and application frameworks;
- Using C++, LabVIEW FPGA and python programming languages and environments;
- Using VHDL, Verilog and high level synthesis languages for FPGA development
- Applying high-integrity software quality assurance processes;

- Delivering high quality technical reports and documentation in English;
- Familiarity with EPICS7 Channel Access and pvAccess communication protocols and EPICS7 ecosystem is considered advantageous;
- Familiarity with the ITER integrated control system architecture, tools and techniques is considered advantageous given the tight schedule.

Behavioural competencies:

- Ability to create and sustain a mutually supportive team work environment;
- Ability to analyse multiple and diverse sources of information to understand problems accurately before moving to proposals.

10 ACCEPTANCE CRITERIA

The following criteria shall be the basis of the acceptance of the successful accomplishment of the Work.

10.1 Delivery date criteria

On-time delivery of deliverables according to the milestone dates defined in Section 7.

10.2 Report and Document Review criteria

Reports and design documentation as deliverables shall be stored in the ITER Organization's document management system, IDM by the Contractor for acceptance. The IO Technical Responsible Officer for this contract is the Approver of the delivered documents. The Approver can name one or more Reviewers(s) in the area of the report's expertise. The Reviewer(s) can ask modifications to the report in which case the Contractor must submit a new version. The acceptance of the document by the Approver is an acceptance criterion.

10.3 Software delivery criteria

Software source code shall be delivered in the ITER Organizations software repository (GIT) by the Contractor for acceptance. The IO Technical Responsible Officer for this contract is the Approver of the delivered software source code.

The acceptance is based on CI reports, source code and quality peer reviews performed with each GIT pull requests, and when technically achievable, release verification reports pertaining to the magnetics plant controller I&C development project.

11 SPECIFIC REQUIREMENTS AND CONDITIONS

None identified.

12 WORK MONITORING / MEETING SCHEDULE

The work will be managed by means of bi-weekly planning and progress meeting and/or formal and informal exchange of documents which provide detailed information. Planning meetings will be organized by the ITER Organization to plan the upcoming activities, review the progress of the work, discuss, and resolve the technical problems.

The main purpose of the bi-weekly meetings is to allow the ITER Organization and the contractor to:

1. Allow early detection and correction of issues that may cause delays;
2. Review the completed and planned activities and asses the progress made;
3. Permit fast and consensual resolution of unexpected problems;
4. Clarify doubts and prevent misinterpretations of the specifications.

On a quarterly basis, the contractor shall submit to ITER Organization an activity report with references to software deliveries and documentation produced during that period.

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

13 QUALITY ASSURANCE (QA) REQUIREMENT

The organization conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system. The general requirements are addressed in ITER Procurement Quality Requirements (ITER_D_22MFG4).

Prior to commencement of the contract, a Quality Plan (QP) should be submitted for IO approval in accordance with Procurement Requirements for Producing a Quality Plan (ITER_D_22MFMW). The QP should describe the organization for the contract; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities.

All requirements of this Technical Specification and subsequent changes proposed by the Contractor during the execution of the Contract are subject to the Deviation Request process described in Procedure for the management of Deviation Request (ITER_D_2LZJHB). When a non-conformance is identified, the contractor are subject to the Non-conformance Report process describe in Procedure for management of Nonconformities (ITER_D_22F53X).

Documentation developed as the result of the contract should be retained by the performer for a minimum of 5 years and then may be discarded at the direction of the IO.

The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, it should fulfil IO document on Working Instruction for the Qualification of ITER safety codes (ITER_D_ 258LKL).

14 SAFETY REQUIREMENTS

ITER is a Nuclear Facility identified in France by the number-INB-174 (“Installation Nucléaire de Base”).

For Protection Important Components and in particular Safety Important Class components (SIC), the French Nuclear Regulation must be observed, in application of the Article 14 of the ITER Agreement.

In such case the External Contractors (Suppliers and Subcontractors, and their Subcontractors) must be informed that:

- The Order 7th February 2012 applies to all the components important for the protection (PIC) and the activities important for the protection (PIA).
- The compliance with the INB-order must be demonstrated in the chain of external contractors.
- In application of article II.2.5.4 of the Order 7th February 2012, contracted activities for supervision purposes are also subject to a supervision done by the Nuclear Operator.