Ref. Ares(2018)4382004 - 24/08/2018

BrightnESS

Building a Research Infrastructure and Synergies for Highest Scientific Impact on ESS

H2020-INFRADEV-1-2015-1

Grant Agreement Number: 676548

Deliverable Report: D3.3 Invitation to Market Consultation

1 Project Deliverable Information Sheet

BrightnESS Project	Project Ref. No. 676548	
	Project Title: BrightnESS - Building a Research Infrastructure and Synergies for Highest Scientific Impact on ESS	
	Project Website: brightness.se	
	Deliverable No.: D3.3.	
	Deliverable Type: Report	
	Dissemination Level: Public	Contractual Delivery Date: 01/12/2017
		Actual Delivery Date: 24/08/2018
	EC Project Officer: Mina Koleva	

2 Document Control Sheet

Document	Title: Invitation to Market Consultation	
	Version: 1	
	Available at: https://brightness.esss.se/about/deliverables	
	Files: -	
Authorship	Written by	Luis Ortega
	Contributors	-
	Reviewed by	Meredith Shirey, Ute Gunsenheimer, Anne-Charlotte Joubert
	Approved by	BrightnESS Steering Board

3 List of Abbreviations

ESS – European Spallation Source ERIC
PICMG – PC Industrial Computer Manufacturers Group
MTCA.4 – Micro Telecommunication Computing Architecture specification 4
PPI – Public Procurement of Innovative solutions
PCP – Pre-Commercial Procurement
R&D – Research and Development
ICS – ESS Integrated Control Systems Division
SPL – ESS Supply, Procurement and Logistics Division
EPICS – Experimental Physics and Industrial Control System
PSI – Paul Scherrer Institut
CERN – Conseil Européen pour la Recherche Nucléaire
PIN – Prior Information Notice
OJEU – Official Journal of the European Union

Table of Contents

4 Executive Summary

The invitation to market consultation (deliverable 3.3) and the market consultation itself are the initial results of implementing task 3.3.2 “preparing the launch of one joint Public Procurement of Innovative solutions (PPI)”. This task, originally “preparing and launch of one joint Pre-Commercial Procurement (PCP)”, was changed to “PPI” following the grant agreement amendment with reference no. AMD-676548-24 and signed the 2nd of August 2017. European Spallation Source’s (ESS) amendment request was based on the following rationale:

1. During the construction phase of ESS, it is almost impossible to identify a project suitable for PCP approach. The technology required for the construction and installation of ESS is in a degree of great maturity and/or readiness. Research and Development (R&D) activities started several years ago and they are in best cases under prototype review and validation stages. Other projects are already in procurement and/or production stages. Therefore, it is not the appropriate time to procure R&D services.
2. ESS Supply, Procurement and Logistics Division (SPL) had identified different areas where a PPI approach would help delivering the construction and installation of systems for ESS. There are cases, such as Micro Telecommunications Computing Architecture Components (MTCA.4) where the market requires a coordinated effort from procurers in order adapt current technology and standardize new products.

The difficulties in identifying a PCP case as well as the amendment request and approval have affected significantly in the schedule for this task. This deliverable was originally planned for December 2017 and it only materialized in March 2018.

SPL, in collaboration with ESS Integrated Control Systems (ICS), identified a suitable procurement project fulfilling the strategy above. This procurement project relates to MTCA.4.

The decision to prepare and launch a PPI for MTCA.4 components was adopted by SPL and ICS during Q1 2017. Following this decision and the amendment of Brightness grant agreement, SPL and ICS initiated activities leading to the organization of a market consultation for this procurement. SPL prepared procurement procedure regarding consultancy support for preparing and conducting a market consultation regarding an innovation procurement procedure. This procurement was launched in June 2017 and the contract was awarded in November 2017 to Addestino Innovation Management. The market consultation was held in Copenhagen the 19th of April 2018 and the invitation to the market consultation was executed the 13th of March 2018.

5 Background

The ICS is a complex network of hardware, software and configuration databases that integrates the operations of all facility infrastructures. The control system at ESS is essential for the synchronization and day-to-day running of all the equipment responsible for the production of neutrons for the experimental programs. It is a distributed system organized in multiple layers. The top layer represents the human machine interfaces and high-level applications that connect to the Control Box, the middle layer, running the Experimental Physics and Industrial Control System (EPICS) control system framework, and to additional services such as the Timing, Machine Protection and archival systems. A great variety of hardware is used for different layers and application requirements.

ICS had selected MTCA.4 as the platform for applications demanding high-speed data acquisition in an early stage of the ESS project. MTCA platform developed from telecommunications hardware. Companies launched a first set of components in 2011 and PICMG established the standards for this modular computing systems. MTCA comprises four different specifications, where MTCA.4 is known as the standard for physics (i.e. research facilities).

While MTCA.4 can be considered a standard, very few research facilities are using this platform. MTCA.4 requires significant developments in order to become the preferred solution for high speed data acquisition solutions. Developments are required in terms of stability, operation, interoperability and adaptation to new architectures. Specific areas for improvement are:

1. Crate design (Improvement of mechanical design, air flow and heat dissipation, health monitoring and software infrastructure management),
2. MTCA Carrier Hub and CPUs (Adaptation to new AMC architectures, PCI bus management, etc.), and
3. Upgraded specifications (speed, power, etc).

ESS' decision was taken assuming and understanding that market available products for the specification MTCA.4 would require technical developments in order to satisfy ESS long-term needs in an efficient manner. Despite the technical challenges, the following key benefits justified ESS decision:

1. MTCA.4 provides computer architecture consistent with Modular Open Systems Approach principles for reduced life cycle costs,
2. MTCA.4 provides the modularity and flexibility required by ESS,
3. MTCA.4 allows fully redundant and non-redundant system configurations including power budgeting and hot-swap
4. MTCA.4 allows complete component definition and system management that allow failure detection and isolation
5. MTCA.4 platform is in an early stage of development and use whereas alternative platforms are approaching the end for their life cycle.

Based on this background, a PPI approach for the procurement MTCA.4 components was preliminarily recommended by SPL. Especially taking into account that ESS would act as a launch procurer for products demanding certain degree of development (but not a full R&D exercise), that are crucial for the success of the ESS project, and that are other research facilities are considering for the future applications. Furthermore, MTCA.4 has been in the agenda of other research facilities in recent years but no one had fully committed to this technology.

6 Report on Implementation Process and Status of Deliverable

Preparing and launching an innovation procurement procedure typically involves the following steps:

1. Needs identification and verification,
2. State of the art assessment,
3. IPR search,
4. Regulatory, certification and standardization environment assessment,
5. Project feasibility study,
6. Market consultation.

ICS had, prior to the decision to follow a PPI strategy, completed activities 1-5 above. With the decision to proceed with a PPI, SPL prepared and launched a procurement procedure in order to contract consultancy support services for preparing and conducting the market consultation, as foreseen in the grant agreement. This procurement procedure concluded in November 2017 with the award of the contract to Addestino. ESS decided to contract expert services in managing innovation dialogues in order to ensure a successful market consultation.

ESS and Addestino kicked-off the activities for the preparation of the market consultation with two meetings in December 2017. During these meetings, it was agreed that ESS would approach other European research facilities (PSI, CERN, ITER, Diamond Light Source) in order participate in the market consultation as potential procurers that could join the PPI. However, ESS efforts to catch the interest of these facilities were unsuccessful.

Despite the absence of procuring partners for the market consultation and later PPI, ESS decided to proceed with the market consultation in March 2018 and implemented the following actions:

1. Submission of a Prior Information Notice (PIN) to the Official Journal of the European Union (OJEU),
2. Publication of a contract notice in ESS e-tender portal and website.

The invitation to market consultation was received very positively by the industry and other interested parties. The market consultation was held the 19th of April 2018, from 10:00 to 16:00 at the Clarion Hotel Copenhagen Airport. Attendance to the market consultation was very good, with 22 participants from industrial players, 4 representatives from institutions collaborating with ESS (DTU, Big Science Denmark, Big Science Sweden and CERIC), 2 representatives from Addestino and 8 representatives from ESS.

The market consultation offered a very good dialogue between ESS and industry. Addestino presented ESS' requirements via use cases. Participants from industry were given a risk assessment scheme in order to rate the risks involved in implementing the product development required to achieve ESS requirements.

In most cases (7 out of 8 use cases), the results from the risk assessment exercise resulted in very low rates. Such results indicate that a PPI approach would be the most suitable strategy in order to procure MTCA.4 components delivering the product innovations required by ESS.

7 Conclusion

The market consultation confirmed the PPI approach as the most suitable procurement strategy for the procurement of MTCA.4 components. Product innovations required by ESS are of great value for the ESS project, the industry and the market. These innovations involve acceptable levels of risk in terms of product development and industrialization, showing that the new generation of products are near-the-market. Furthermore, the PPI, where ESS would act as a launch procurer, will help developing the MTCA.4 platform and the market attracting interest from other potential procurers.

The implementation of the PPI should take form via a competitive/negotiated procedure/s. Such a procedure would allow for necessary negotiations and products conformance testing before the award of

the contract/s. Moreover, taking into account that ESS is preparing to launch this procurement independently, the recommended procedure is the competitive procedure with negotiation in accordance with article 15 of the European Spallation Source ERIC Procurement Rules.
Finally, it is essential for ESS that the new generation of MTCA.4 components translate into a new standard and that the market develops with new customers. ESS shall continue pushing MTCA.4 platform via collaborations with industry and other research facilities within the PICMG.

8 Annexes

1. Prion Information Notice 2018/S 050-110014
2. Participant List – Market Consultation
3. Market Consultation regarding innovations on MTCA.4 required for ESS Final Report

This notice in TED website: http://ted.europa.eu/udl?uri=TED:NOTICE:110014-2018:TEXT:EN:HTML

Sweden-Lund: Parts of computers
2018/S 050-110014

Prior information notice

This notice is for prior information only

Supplies

Directive 2014/24/EU

Section I: Contracting authority

I.1) **Name and addresses**

European Spallation Source ERIC
Tunavägen 24
Lund
223 63
Sweden
Telephone: +46 468883000
E-mail: luis.ortega@esss.se
NUTS code: SE224
Internet address(es):
Main address: https://europeanspallationsource.se
Address of the buyer profile: https://europeanspallationsource.se/procurement/listings

I.2) **Joint procurement**

I.3) **Communication**

Additional information can be obtained from the abovementioned address

I.4) **Type of the contracting authority**

Other type: European Research Infrastructure Consortium

I.5) **Main activity**

Other activity: Research

Section II: Object

II.1) **Scope of the procurement**

II.1.1) **Title:**

Market Consultation regarding innovations on Micro Telecommunications Computing Architecture specification 4 (MTCA.4) required for the European Spallation Source

Reference number: 84

II.1.2) **Main CPV code**

30237100

II.1.3) **Type of contract**

Supplies

II.1.4) **Short description:**

The European Spallation Source ERIC will be holding the market consultation meeting on 19.4.2018, from 10:00 to 16:00 at the Clarion Hotel Copenhagen Airport in order to consult with experts regarding the ambition of the ESS project and the definition of suitable solutions that can be developed within the timeframe and budget of the ESS project.
Please register your interest if you want to participate in the market consultation and ESS will contact you and provide additional information. URL for registration of interests (https://www.kommersannons.se/ess/Notice/NoticeOverview.aspx?ProcurementId=3264).

II.1.5) **Estimated total value**

II.1.6) **Information about lots**
This contract is divided into lots: no

II.2) **Description**

II.2.1) **Title:**

II.2.2) **Additional CPV code(s)**

II.2.3) **Place of performance**
NUTS code: SE224

II.2.4) **Description of the procurement:**
Description:
Within the framework of an intended procurement for innovative MTCA.4 components, ESS is pleased to invite you to a market consultation that will be organized in Copenhagen on the 19.4.2018.
Objective of the market consultation:
ESS is one of the largest science and technology infrastructure projects being built today. The facility design and construction includes the most powerful linear proton accelerator ever built, a 4-tonne, helium-cooled tungsten target wheel, 2 dozen state-of-the-art neutron instruments, a suite of laboratories, and a supercomputing data management and software development center. The control system at ESS is essential for the synchronisation and day-to-day running of all the equipment involved in the production of neutrons for the experimental programs. ESS aims to develop and implement a control system infrastructure for the facility upon MTCA.4 technology and several product innovations can be identified for the technology to reach performance and availability requirements for ESS.
The market consultation is planned as an opportunity to interact and cooperate with potential suppliers and stakeholders in order to detect and discuss innovative solutions addressing ESS needs and the feasibility of such innovations.
The Public Procurement of Innovation (PPI):
Based on insights and findings gathered during the market consultation, ESS will consider launching a PPI with the intention to act as a launch customer for the innovative MTCA.4 components. Additional information on the PPI will be provided at the market consultation.

II.2.14) **Additional information**
The European Spallation Source ERIC will be holding the market consultation meeting on 19.4.2018, from 10:00 to 16:00 at the Clarion Hotel Copenhagen Airport in order to consult with experts regarding the ambition of the ESS project and the definition of suitable solutions that can be developed within the timeframe and budget of the ESS project.

II.3) **Estimated date of publication of contract notice:**
15/06/2018

Section IV: Procedure

IV.1) **Description**

IV.1.8) **Information about the Government Procurement Agreement (GPA)**

The procurement is covered by the Government Procurement Agreement: no

Section VI: Complementary information

VI.3) **Additional information:**

VI.5) **Date of dispatch of this notice:**

12/03/2018

brightness

PARTICIPANTS LIST

Date of the meeting: 19 April 2018

Location of the meeting: Clarion Hotel Copenhagen Airport

Work Package & Task: Work Package 3 / Task 3.3

Purpose/Title of the Meeting: Market Consultation Regarding Innovations on Micro Telecommunications Computing Architecture Specification 4 (MTCA.4) for the European Spallation Source

No.	Last Name	First Name	Organisation	Signature
1	Broomé	Ulf	Pentair Technical Solutions Nordic AB	
2	Martin	David	Pentair Technical Solutions Nordic AB	
3	Ganninger	Christian	Pentair Technical Solutions Nordic AB	
4	Waldt	Ralf	Pentair Technical Solutions Nordic AB	
5	Möllers	Ralf	Elma Electronic GmbH	
6	Berner	Thomas	Wiener Power Electronics GmbH	
7	Dirksen	Vollrath	N.A.T. GmbH	Vollrath Dirk
8	Shearer	Ian	VadaTech Ltd	
9	Prictoe	Paul	Concurrent Technologies PLC	

No.	Last Name	First Name	Organisation	Signature
10	García	Iván	IOxOS Technologies	
11	Braidotti	Enrico	CAEN ELS s.r.l.	
12	Kirsch	Matthias	Struck Innovative Systeme GmbH	
13	Kiepiela	Marcin	Creotech Instruments S.A.	
14	Sowinski	Mikolaj	Creotech Instruments S.A.	
15	Ulskov Sørensen	Brian	RECAB	
16	Axbøg	Brian	RECAB	
17	Koetsier	Cees	RECAB	
18	Moreno	Javier	GMV	
19	Sarasola	Iciar	GMV	
20	Orban	Janos	Evopro Innovation Ltd	
21	~~Szepessy~~	~~Zsolt~~	Evopro Innovation Ltd	
22	Ljungkvist	Peter	Combitech AB	
23	~~Schultz~~	~~Fredrik~~	~~Combitech AB~~	
24	~~Staffeldt~~	~~Jon~~	~~Combitech AB~~	

brightness

No.	Last Name	First Name	Organisation	Signature
25	Montoya	Eladio	Thales Alenia Space Spain	
26	Buyse	Dominique	Addestino	
27	De Prycker	Thomas	Addestino	
28	Carling	Henrik	European Spallation Source ERIC	
29	Ortega	Luis	European Spallation Source ERIC	
30	Menninga	Mirko	European Spallation Source ERIC	
31	Strick	Dusan	European Spallation Source ERIC	
32	Joubert	Anne-Charlotte	European Spallation Source ERIC	
33	Korhonen	Timo	European Spallation Source ERIC	
34	Farina	Simone	European Spallation Source ERIC	
35	Jensen	Arne	Big Science Denmark	
36	Cazacu Hansen	Anca Cornelia	Technical University of Denmark	
37	Girod	Matthias	CERIC	
38	Larsson	Mats	Big Science Sweden	
39	Pitruzzella	Marco	CEGELEC	
	Weijsner	Mattias	Preet / Load	

Market Consultation regarding innovations on Micro Telecommunications Computing Architecture specification 4 (MTCA.4) required for the European Spallation Source (ESS)

Final report

T: +32 52 69 02 69 | E: info @addestino.be | W: www.addestino.be

Addestino Innovation Management
Company nr. BE 0886.037.986
www.addestino.be
Dominique.Buyse@addestino.be
tel: +32 52 69 02 69
Nachtegaalstraat 6W2,
9240 Zele, Belgium

Contents

1 Context

The European Spallation Source ERIC (ESS) is one of the largest science infrastructure projects being built in Europe today. Its mission is to build the most powerful neutron source in the world. As a parallel activity, ESS is leading a project on capacity building in innovation procurement under the Horizon 2020 “BrightnESS” research and innovation program. ESS deliverables within this sub-project include a market consultation and tender documents for an innovation procurement procedure. Horizon 2020 BrightnESS action is a programme that involves 18 Consortium Partners supporting the construction and ensuring the maximum scientific and technological impact via spreading the knowledge to relevant stakeholders.

ESS has chosen MTCA.4 as the standard technology for high-speed data acquisition applications. MTCA (Micro Telecommunications Computing Architecture) originated from telecommunications hardware and was formally introduced by PICMG (PC Industrial Computer Manufacturers Group) in September 2006 as a standard describing a new class of modular computer systems. MTCA has evolved to become a standard for demanding applications in large-scale research facilities e.g. particle accelerators, high-energy physics, plasma fusion sources, etc.

While the MTCA is a standard, there is still room for development in terms of the stability, operation, interoperability and adaptation to new architectures. Potential areas of improvement in terms of innovation are: crate design (Improvement of mechanical design, air flow and heat dissipation, health monitoring and software infrastructure management), MTCA.4 Carrier Hub and CPUs (Adaptation to new AMC architectures, PCI bus management, etc.) and upgraded specifications (speed, power, etc).

Therefore, ESS aims to procure MTCA.4 components including innovations in the areas indicated above.

2 Objectives and way of working

2.1 Background and objectives

This final report describes the steps taken during the market consultation for MTCA.4 at ESS. It contains the results of the workshops as well as recommendation for the next steps. The goal of this final report is a recommendation for the most appropriate procurement procedure. To be able to achieve this ESS experts and the industry where brought together to collect knowledge, insights and concrete proposals from different point of views.

This final report answers following questions:

- What are the main requirements ESS has regarding MTCA and more specific the MTCA.4 extension?
- What are the timelines?
- Which procurement procedure should be followed for every requirement?
- How can these requirements become part of a new version of the MTCA.4 standard?

Addestino Innovation Management was selected by the European Spallation Source (ESS), as part of the Horizon 2020 BrightnESS action program, to guide the market consultation. Addestino's mission is to deliver innovation to its customers, end-to-end, from idea to result. This mission is achieved based on 3 central pillars:

- Addestino is a multidisciplinary team which is capable to realize innovation through business, strategy, technology and user experience.
- Addestino masters an iterative end-to-end methodology to reduce risk and to accelerate successful product delivery.
- Addestino contains in depth technology knowledge and uses this in a pragmatic way for multiple industry segments (telecommunication, healthcare, energy, transport, electronics, etc.) in a broad range of environments (start up, SME, multinationals, universities, research facilities and governmental)

During the market consultation Addestino has taken up the role as external moderator. In this role Addestino coordinated and facilitated the market consultation, guided and moderated the discussions and stimulated the interaction between multiple parties. As external moderator, Addestino has always guarded the common goals, with the alignment between the parties as main objective. Addestino also provided the needed expertise and insights in innovation. This was done by the use of a custom-tailored plan and using proven methodology to guide in depth discussions during the workshops.

The activities leading to the market consultation started in December 2017 and the market consultation was done in April 2018. The process consisted of 4 steps:

1. **The scoping session** with members of the project (ESS) to answer the key questions of the project. Which requirements are in scope and which requirements are out scope? Which constraints to consider versus which degrees of freedom to offer? Which decisions/knowledge is already "fixed" versus what is variable? Which ambition-level versus which risk-level is tolerated? After this session the project goals were set.

2. **The requirement & use case gathering session** with members of the project team (ESS) and some domain experts from ESS to collect all requirements and use cases, functional and non-functional. Always with a clear understanding of the drivers behind these requirements. All the use cases were prioritized based on the value for ESS.
During this session a detailed plan with milestones and their according timing was made to make sure ESS will be able to have the new products on time.
3. **The market consultation** with the industry to obtain a clear understanding by the industry players of their solutions to deliver the requirements. Hence identify technical risks to meet all requirements. Prioritize technical risks in terms of innovation potential from a "technical perspective", i.e. how novel is a requirement compared to the state-of-the-art.
4. **The final report** made by Addestino based on the information collected during all the sessions.

2.2 Participants during the market consultation

Due to the open character of the market consultation and for transparency all participating entities are listed below

Pentair Technical Solutions Nordic AB
Elma Electronic GmbH
Wiener Power Electronics GmbH
N.A.T. GmbH
VadaTech Ltd
Concurrent Technologies PLC
IOxOS Technologies
Struck Innovative Systeme GmbH
Creotech Instruments S.A.
RECAB
GMV
Evopro Innovation Ltd
Combitech AB
Thales Alenia Space Spain
European Spallation Source ERIC
Big Science Denmark
Technical University of Denmark
CERIC

3 Summary

This section is the summary of the workshops & market consultation regarding MTCA.4 at ESS. It contains the fully worked out results obtained during the process. A recommendation for the next steps, the advised procurement procedure on the short term, as well as a recommendation on how to incorporate the requirements in the MTCA standard on the long run are described in this document. The conclusions can be split up in short term and long term.

On short term, assessment has shown that all the use cases are relevant for ESS (and other research facilities) and that they can be achieved by the industry within the wanted timeframe. These use cases all fit within the area of Public Procurement of Innovative Solutions, not of the shelf, but definitely feasible.

On the long term, standardisation will bring ESS, and other research facilities, lots of benefits. However, to achieve this in time, ESS will need to take an active role in the MTCA.4 standardisation group (PICMG). This will require time from the MTCA.4 experts at ESS.

4 MTCA.4 at ESS explained

4.1 Technology selection

ESS has selected MTCA.4 as a way to replace VME and CompactPCI® in research because of its performance vs total cost of ownership. VME & CompactPCI® are legacy technologies and are not attractive for research facilities with a long forecasted lifetime. The main drivers for MTCA.4 are:

- very high reliability and redundancy
- a forecasted lifetime of 40 years
- a backplane architecture (LVDS) which accommodates future PCI Express & Ethernet
- possibility to customise
- the install & replace TCO (Total cost of ownership) massively exceeds the equipment CAPEX.

However, improvements are needed to fit the research needs.

4.2 Short & Long-term commitment

On the short term, ESS is already installing MTCA.4 equipment, as is shown in the picture below. However, the target is to install the improved MTCA.4 equipment in Q4 2019. These products will be MTCA.4 compliant products, but will contain the non-standardized improvements needed by ESS. On the long term, starting in 2022, the replacement wave will start which will replace the already installed equipment. The goal during this wave is to install products with the requirements as defined in this report, but as part of a new MTCA.4 standard. This planning is visualized in Figure 1.

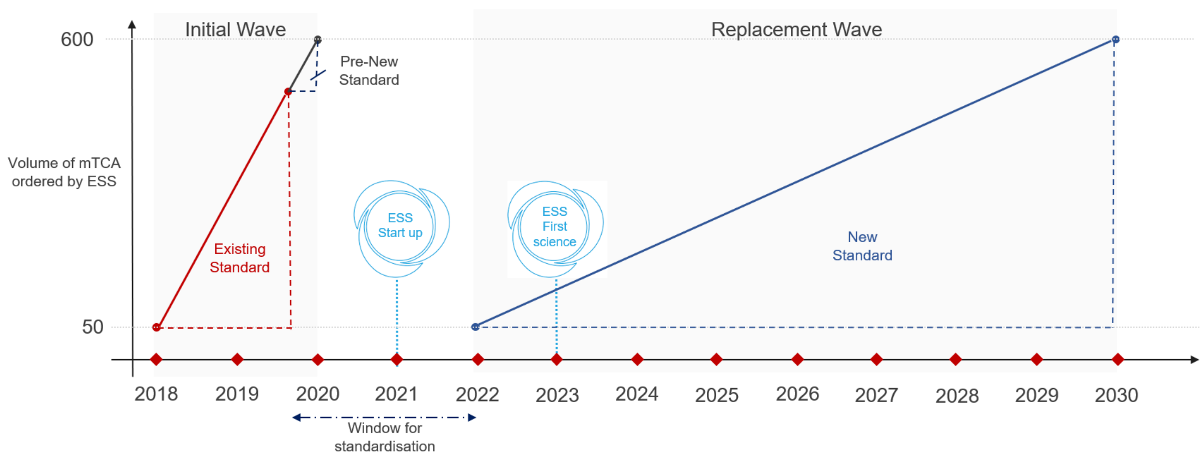

Figure 1: Short and long-term planning

In order to have pre-new standard MTCA.4's operational in initial wave, ESS is aiming to have the Contract Notice / Invitation to Tender out by end of June. This will give the industry 1 year for the necessary R&D and production of the first prototypes. Another 3 months will be available for the next production batch. These timings are visualised in Figure 2.

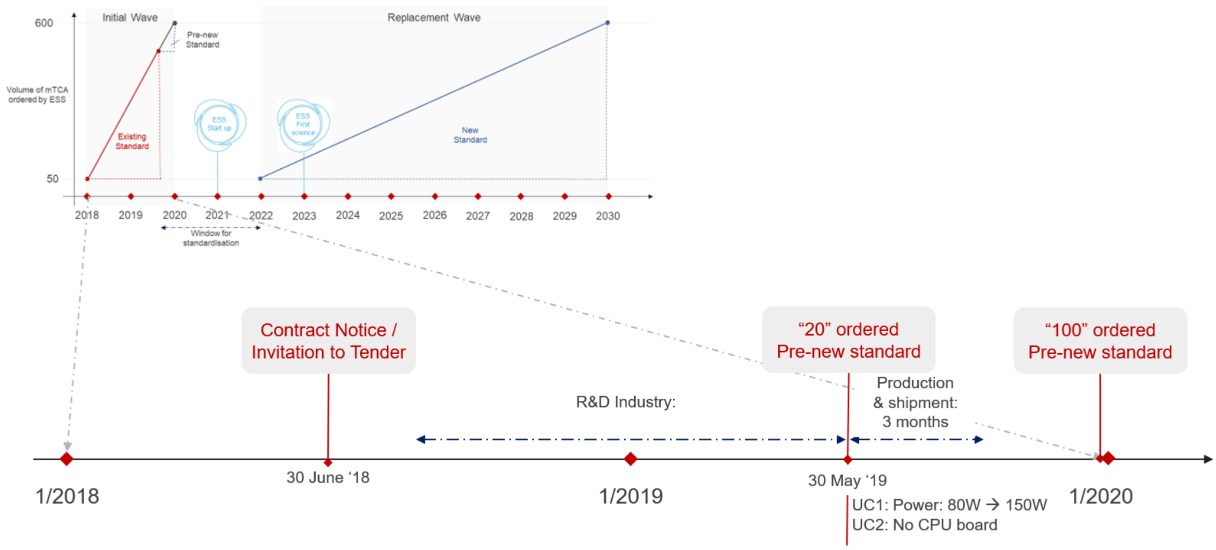

Figure 2: Plan for pre-standard MTCA.4

5 Requirements

5.1 Collection of the requirements

During the workshop with ESS a list of 7 requirements was created. These requirements are formatted as a use case. A use case contains who the requirement is for (as a…), what is needed (I can..) and why it is needed(so that…).

After the requirement gathering, the requirements were scored to define the value for ESS. When assessing the use cases, the value interpretation in Table 1 was used.

Score	Description
0	Couldn’t care less, no added value.
2-3	Nice to have, if we have the time and resources
13	Must have!
20+	WOW! Homerun!

Table 1: scale for value

All use cases and their scoring can be found in Table 2.

ID	As a…	I can..	So that…	Value score
①	As a scientist	I can increase the power from 80W to 150W per slot	so that we can use the full processing power of the board (AMC) to support my latest and greatest algorithms	40
②	As a control system architect	I can eliminate the dependency on a central CPU board and replace it by an onboard controller on the MCH to do PCI bus enumeration and other housekeeping functions	so that we don't have to sacrifice a slot nor have to spend the money on a separate CPU	40
③	As a control system architect	I can install an MTCA.4 system where I can choose which direction the airflow goes (front/back, top/down, sideways, ?..)	so that I can fit the MTCA.4 system into the constraints of the rack space which is allocated to us	20
④	As a control system architect	I can increase the bandwidth of the backplane from 10Gbps to 40Gbps	so that I can keep up with technology evolution, and that we are not hitting a performance barrier for scientists in the future	13
⑤	As a control system architect	I can increase the bandwidth of the backplane from 10Gbps to 100Gbps	so that I can keep up with technology evolution, and that we are not hitting a performance barrier for scientists in the future	8
⑥	As a scientist	I can increase the quality of the power supply (< 2mV peak-peak, 0 - 50 MHz ripple and noise)	so that I can use it for more sensitive analog equipment such as for delicate proton beam positioning monitors	13
⑦	As a scientist	I can decrease the latency of the PCIe bus (33% lower latencies)	so that I can have faster acquisition rates and feedback loops	8

Table 2: List of use cases

5.2 Assessing the use cases for risk

During the industry session all use cases were assessed by the industry for risk using the planning poker methodology. The higher the risk, the less likely it will be feasible to deliver the requirement within a reasonable time frame. When assessing the use cases following value the interpretation in Table 3 was used.

Score	Description
0	No worries, off-the-shelf standard solutions exist.
2-3	A frequent problem, potentially some tricky cases, but certainly solvable.
5-8	Significant attention, effort and risk reduction required to be successful.
13	Absolutely not a standard problem. A solution requires important choices, thorough elaboration, and specific expert effort. Success can be achieved with significant time and effort.
100	Impossible, requires physical laws breakthroughs.
?	Don't know, no experience with this subject.

Table 3: scale for risk

Use Case 1: As a scientist I can increase the power from 50W to 150W per slot so that we can use the full processing power of the board (AMC) to support my latest and greatest algorithms.

Risk score: 3

Increasing the power is definitely feasible as it is already available in other standards (e.g. VME currently has 6KW). For MTCA.4 a non-standard power supply is already of the shelf available (Vadatech already provides a MTCA.4 PSU with 360W per slot). The biggest challenge will be cooling, as using more power will produce more heat. There might also be a need to change the connectors.

Another approach could be to reduce the power usage, which is an ongoing trend in the electronics industry.

Use case 2: As a control system architect I can eliminate the dependency on a central CPU board and replace it by an onboard controller on the MCH to do PCI bus enumeration and other housekeeping functions so that we don't have to sacrifice a slot nor have to spend the money on a separate CPU.

Risk score: 3

This use case has already been raised by the industry to certain vendors and has already been implemented. So it is definitely feasible. It can be done using a low power, low functionality and low-cost CPU or by using 1 core of a multicore CPU. A redesign might be needed however.

Use case 3: As a control system architect I can install an MTCA.4 system where I can choose which direction the airflow goes (front/back, top/down, sideways, ?..) so that I can fit the MTCA.4 system into the constraints of the rack space which is allocated to us.

Complexity differs if it is only front/back or top/down or the combination so the use case needs to be split up. This use case was assessed with following constraints for the crates: a height of 9U & fully loaded.

Use case 3a: As a control system architect I can install an MTCA.4 system where I can choose which direction the airflow goes top/down so that I can fit the MTCA.4 system into the constraints of the rack space which is allocated to us.

Risk score: 3

Changing the up/down direction is definitely feasible. It could be done by reversing the fans without replacement or by installing reverse fans. The biggest risk here is hot spots as boards are designed for a certain air flow. A redesign of the board could be needed.

Use case 3b: As a control system architect I can install an MTCA.4 system where I can choose which direction the airflow goes left to right or visa versa so that I can fit the MTCA.4 system into the constraints of the rack space which is allocated to us.

Risk score: 8

MTCA.4 is a vertically design system so a horizontal air flow will create some issues with hot spots. However horizontally designed systems already exists in the market (like MTCA.0). Redesign might be needed and will be more extensive compared to use case 3a. A way to easily identify hot spots will be useful.

Use case 3c: As a control system architect I can install an MTCA.4 system where I can choose which direction the airflow goes with full flexibility (vertical & horizontally) so that I can fit the MTCA.4 system into the constraints of the rack space which is allocated to us.

Risk score: 40

This use case will create a lot of issues. The space constraints won't be easy to fix & a lot of redesign to fix hot spots will be needed. Designing a system to be vertically & horizontally oriented will be extremely challenging.

Use case 4: As a control system architect I can increase the bandwidth of the backplane from 10Gbps to 40Gbps so that I can keep up with technology evolution, and that we are not hitting a performance barrier for scientists in the future.

Risk score: 8

Note: The 40Gbps is concatenated, so not per lane, but 4x10Gbps.

Currently the industry is already looking at this requirement. Other connectors might be needed for the AMC & the MCH, but these are currently available on the market. For the rest it is just a matter of standardisation.

Use case 5: As a control system architect I can increase the bandwidth of the backplane from 10Gbps to 100Gbps so that I can keep up with technology evolution, and that we are not hitting a performance barrier for scientists in the future.

Risk score: 13

On short term this can be achieved by emulating this speed between neighbouring boards using more pins, this does not provide the speed between all boards, but should be sufficient for most use cases.

On the long term it is probably feasible to have a full 4x25Gbps backplane. This has be verified in simulations. Doubts exists on the other hand that the connectors will be a blocking factor to have this speed between all boards. However, a full redesign of the full back plan will be needed, a PCB redesign will be need, recertification will be needed, and so on. Also, an assessment on using a different backplane material needs to be which will impact the price. And backwards compatibility also needs to be guaranteed. So, to achieve this speed, a full redesign of all components is needed. This will only be feasible if it is part of the standard.

Use case 6: As a scientist I can increase the quality of the power supply (< 2mV peak-peak, 0 - 50 MHz ripple and noise) so that I can use it for more sensitive analog equipment such as for delicate proton beam positioning monitors.

Risk score: 5

Currently power supplies with <10mV peak-peak @200MHz exists and <4mV peak-peak could definitely be done. <2mV peak-peak will need some redesign but is definitely doable as <2mV peak-peak is currently standard for detection supplies.

Use case 7: As a scientist I can decrease the latency of the PCIe bus (33% lower latencies) so that I can have faster acquisition rates and feedback loops.

Risk score: 8

The hardware is not the limiting factor for latency. Reducing the latency needs to be done on chip level. For this 2 possibilities exist.

1. New PCIe asics can be designed with lower latency. If there is enough push from the industry to reduce the latency this will be achieved by the ASIC manufacturers.
2. By using VHDL to program an FPGA, reduced latency on the PCIe bus is definitely feasible.

6 Conclusion

On short term ESS aims to procure the improved MTCA.4 products, on the long term the standardisation of these improvements is targeted. This section gives a recommendation on which procurement procedure to select for every use case. It also describes a path to succeed in the standardisation process. It is advised ESS works on short and long term goals in parallel.

6.1 Short term: Procurement of pre-standard MTCA.4 equipment

ESS uses 2 innovation procurement methods to buy not of the shelf available solutions: Public Procurement of Innovative Solutions & Pre-Commercial Procurement. For of the shelf solutions a standard procurement procedure is used. The feedback from the industry, as gathered during the market consultation, is used to select the appropriate procurement procedure.

The Public Procurement of Innovative Solutions is a procedure that can be used to procure innovative solutions:

- The procedure is selected if the solution is not yet commercially available but on/near the market.
- The procurer:
  - Will engage with suppliers in a staged approach using one of the standard procurement procedures
  - Will involve multiple alternative solution comparison
  - May perform/require conformance testing
  - Announces the intention to buy significant volumes
  - Will act as a first buyer
- The procedure will triggers market, knowledge and IPR development.

The Pre-Commercial Procurement procedure is a procedure that can be used in order to procure R&D services from industry:

- The procedure is selected for solutions that are not available in the market and require R&D services (> 50% of investment)
- The procurer:
  - Will engage with several suppliers in a staged procedure
  - Will work with the market based on risk-benefit sharing principle
  - Will involve alternative solution comparison
- A competitive development will be done in phases
- It is intended for the procurement of prototypes only (> 1, ideally)
- Implies significant knowledge transfer (IPR)
- May be followed by a subsequent procurement procedure (commercial solutions).

All use cases are mapped on the value risk matrix in Figure 3 and are grouped per appropriate procurement procedure. The vertical axis indicates the value for ESS. The horizontal axis describes the risk as assessed by the industry.

For ESS it only makes sense to invest in the use cases with a significant value.

Use cases with a low risk level can be procured with a standard procurement mechanism. If the risk level is limited, which is more or less between 3 & 13 a PPI is advised as this risk implies it is near/on the market. If the risk level is assessed as higher the Pre-Commercial Procurement procedure is advised as this implies some serious R&D is needed.

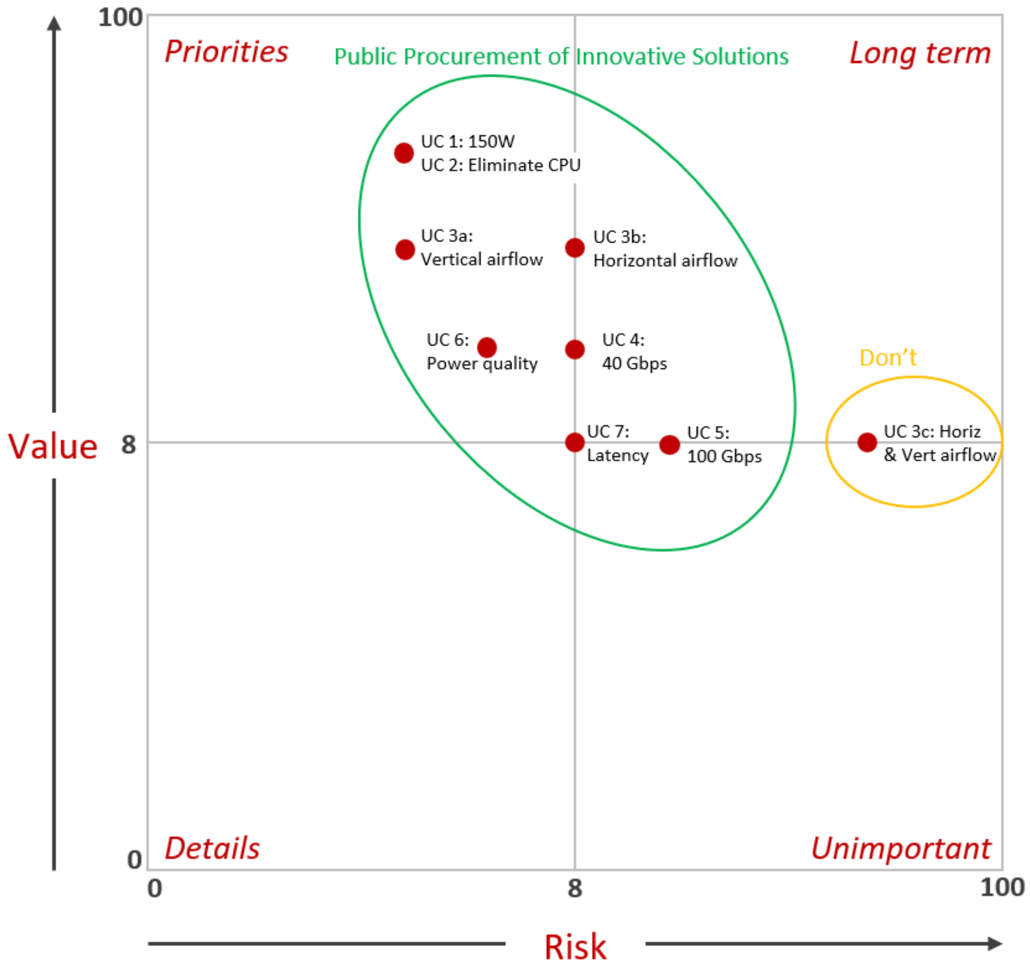

Figure 3: risk and value mapping of all use cases

On the value-risk matrix in Figure 3 on can easily see that a PPI should be done for all use cases. The only exception is use case 3c (horizontal & vertical air flow) which was assessed as to risky, and as the value for ESS is not high enough to start a PCP, the advice is to not take this use case in scope. For Use case 5 (100Gbps backplane) it is advised to only assess the emulation solution, as the full solution will only be possible after the standardisation.

6.2 Long term: Standardisation

For ESS it is very important that the use cases in this final report will become part of the MTCA standard for multiple reasons. First of all, ESS will have more purchasing freedom, as more vendors will support these features. Secondly, other research facilities have also shown interest in the enhanced MTCA.4 products. Standardization of MTCA.4 will enhance the ease of procurement and interest of other facilities, which leads to a bigger market for MTCA.4. In turn, this results in lower prices due to scale effects. Finally, use case 5 (100Gbps backplane) is only fully possible if the 100Gbps requirement is part of the standard as it requires a full redesign of all components.

The best way to form a new standard is when the market pushes for this standard. And, the stronger/bigger the market, the quicker the standardisation process will go. For reference: the current MTCA.4 specification exists due to the heavy push from Desy.

In order to achieve the market push, a broad alliance needs to be build. First ESS needs to enlarge its market power by onboarding other research facilities with comparable needs. Secondly, a workgroup with research facilities and the industry (preferably with the industry partners involved in phase 1) should be formed. This group should then be presented to the PICMG group to work on the standardisation. During this phase it will be the responsibility of the research facilities to keep the focus of the workgroup on the key requirements.

This will require heavy involvement from ESS employees.