Alberto Facco 23/04/2018

Report of the 17th Meeting of the ESS Technical Advisory Committee
Lund, 11-13 April 2018

1. Introduction

The 17th meeting of the ESS Technical Advisory Committee (ESS-TAC) took place in Lundon 11-13 April 2018.

The meeting followed the agenda given in Annex 1. The Committee was given a specific charge (Annex 2), addressed in the meeting and answered in the oral report presented in the closeout session on 13 April 2018. The report constitutes section 3 of this document.

2. Participants in TAC

Present:

Maud Baylac (CNRS, France)	
Cyrille Berthe (GANIL, France)	
Tim Broome (ISIS, UK-retired)	
Michael Butzek (FZJ, Germany)	
Alberto Facco (INFN-LNL, Italy)	*[chair]*
Phillip Ferguson (SNS, USA)	*[co-chair]*
Masatoshi Futakawa (JAEA, Japan)	
Mark Heron (Diamond, UK)	*[co-chair]*
Shane Koscielniak (TRIUMF, Canada)	*[co-chair deputy]*
Roland Mueller (HZB, Germany)	
Jurgen Neuhaus (TUM, Germany)	
Bernd Petersen (DESY, Germany)	
Michael Plum (SNS, USA)	
Igor Syratchev (CERN, Switzerland)	
Szabina Török (MTA EK, Hungary)	
Hans Weise (DESY, Germany)	
Jörg Welte (PSI, Switzerland)	
Karen White (SNS, USA)	

Excused: Frank Gerigk (CERN, CH), Francisco Martin Fuertes (CIEMAT, Spain)

3. Report of TAC17

ESS Technical Advisory Committee
Summary Report of the 17th Meeting
Lund, 11-13 April 2018

A. Facco for the ESS-TAC

General TAC17

- The Committee is grateful to the organizers for their hospitality
- The meeting was well organized
  - The site visit, although taking more time than originally planned, was very instructive and gave us a direct view of the facility construction status
  - The very informative IK contributors poster session was very much appreciated
- Charges to Committee were clearly set
- Most of the relevant meeting documents have been made available to Committee with sufficient time in advance.
  - Answers and comments to previous TAC recommendations should be all made available at least one week before the meeting.
- ESS presentations were of very good quality
  - TAC recommends focused talks avoiding redundant or repeated information. Speakers should leave 5' for discussion in their allotted time
  - For future reviews, more time available for closed sessions of the TAC at the end of every day would be helpful

General TAC17 findings - Project status

- The Committe commends the the ESS team for the significant progress achieved since the last TAC16 meeting.
- Impressive advancement in Conventional Facilities construction toward readiness for installation phase.
  - All ESS personnel will be soon moved to ESS site
- Ion source and LEBT mounted in its final position in the linac tunnel
- Valuable progress reported in the construction of linac components by IK contributors
  - MEBT, DTL, Spoke cavities and CM prototype, Elliptical cavities, RF system, etc.
- R&D on Klystrons and IOT nearly concluded – a decision on the RF sources configuration for the high-beta cryomodules can now be taken
- Progress reported in ESS labs and test facilities

General TAC17 findings - Project status

- Cryogenic plants on track
- Progress in planning and organization of the installation phase
- Recruiting is still proceeding with opening of high level key positions
- Good progress in ICS organization and staffing. The team looks now numerically adequate to the scope

General concerns from the Committee

- The bunker design continues to struggle. This scope should be added to t-TAC and presented at TAC18.
- The Active Handling Cell program is seeing cost and schedule increases. Additional focus should be given to this task.
  - We recommend a workshop with ESS, RACE, and operating facilities where experience and design concepts can be shared
- Administrative problems delaying critical procurements of some of the IK contributors could in several cases find a solution. Nevertheless, many sources for critical delays (VAT, administrative, cash flow, technical problems) are still present and need to be removed
- Projected delays in critical deliveries called for a re-baselining of the project with a slippage in the Beam on Dump date. This is likely to reduce the already limited float in the project, increasing the risk of delays in the Beam-on-Target date.
- The validation test of the medium-β cryomodule was delayed due to accidental rupture of one RF coupler window. This might cause delays in the CM design finalization and in the procurement of CM components

General comments from the Committee

- ESS coordinators who are fully responsible for the readiness, commissioning and performance of a complete subsystem (e.g. front end, MEBT, DTL, etc.) should be assigned. This responsibility should include all subsystem equipment, including ancillaries, controls, machine protection and personnel protection.
  - This scheme would result in a strong transfer of ownership from IK contributors to ESS and better guarantee the system readiness at the start of operation.
- Although a clear picture of the technical personnel requirements for the installation phase is not yet fully achieved, a reinforcement of the Accelerator group is likely needed in view of the future machine operation.

Critical topic: Klystrons vs. IOT

- R&D phase on high power IOT for ESS is nearly concluded. Important results have been obtained, as well as sufficient information for a reliable evaluation of IOT as a candidate RF source for the high-β cryomodules.
- ESS high-power IOTs are on the cutting edge of RF technology, reaching higher efficiency than klystrons around 1 MW. This is not only a success of the ESS RF group but also a very important achievement for the particle accelerators community, which could especially benefit future, high duty cycle machines.
- For the particular case of the ESS high-beta cryomodules, however, the detailed evaluation of cost/benefit of IOTs, in comparison with the klystrons already planned for the medium beta cryomodules, shows substantial equivalence between the two.
- Having two different systems with similar characteristics in the same facility involves duplication of spare parts, operational procedures, personnel expertize, management activities, maintenance tools etc., without any significant resulting benefit.
- **TAC recommends to use only the baseline ESS 1.5 MW klystrons for all the elliptical cryomodules to reduce overall cost and risk of delays**

Answers to previous recommendations

- *Have the recommendations and concerns expressed by TAC16 been addressed adequately?*

Generally Yes, with some exceptions
(see detailed answers in specific sections)

Answers to charges

- Charges of TAC 17 were specific for the a-TAC, t-TAC and c-TAC sub-committees. All answers are reported in the specific sections of this report.

Proposed topics for TAC18

Accelerator

- Readiness Reviews, Commissioning Leaders
- Hardware and Beam Commissioning Status and Results
- Supply chain and Contribution flow from industry and IK
- Machine Protection System design and implementation status
- Integrated Tunnel Installation Plan

Target

- Plans for Operations Crew Training An update on bunker design and procurement at TAC18

Report of a-TAC17
11-13 April 2018

Shane Koscielniak (Chair), Maud Baylac, Bernd Petersen,
Michael Plum, Igor Syratchev, Hans Weise

Excused: Frank Gerigk

Summary of a-TAC Recommendations

1. The ESS project re-baselining requires sufficient in depth information from all in-kind partners. The regular update is a "must". Established project management tools for early warnings should be used and respected.
2. Revising the baseline design to power the entire installed SRF linac with the same modulator and the same klystrons throughout will yield simplifications, schedule benefits, interchangeability and some immediate cost reduction.
3. Without under-mining existing management structures, introduce a "head of commissioning" for each accelerator section. This person should be ultimately responsible for the successful commissioning and operation of that portion.
4. Perform beam readiness reviews for all accelerator sections.
5. Enforce use of administrative tools for commissioning: e-log and e-faults
6. Clarify the plan of how the three loss detection mechanisms will be progressively used to ensure the <1W/m loss rate will be achieved.
7. A procedure should be identified to review the scope of MPS interlocks as they apply to damage that can be caused by the proton beam.
8. The activities of Linde Kryotechnik to fix the cold compressor issues should be carefully followed and observed.

Have the recommendations and concerns expressed by a-TAC16 been addressed adequately? [1]

1. Hold integration reviews selectively, according to needs, and avoid the introduction of yet another formal review series. *YES ADEQUATE*
2. Handbook and processes should be reasonably applied. Complicated, critical and complex items will need full application of all processes. For simpler items, only the core process may be applied. Where equivalent processes already exist at contractors or in-kind contributors, it may be preferable to keep their procedures. *YES ADEQUATE. SEE ESS-0092276*
3. Insist on as-built drawings and specs, (also requested by Spatial integration). *YES ADEQUATE. HOWEVER, additionally, insist on test results of equipment delivered by industry & IK.*
4. Central spatial integration is strongly recommended to have one global vision of all facilities and to have one central reference for volume allocations and 3D interfaces. The present approach is comprehensive but may need streamlining to be sustainable throughout the installation phase. *YES. Use of 3D laser scans has become an established tool.*
5. We strongly recommend to keep the nominally foreseen staffing level to avoid delays of the installation and commissioning phase and to avoid shortcomings in QA/QC and documentation. *TAC understand that it cannot be fully addressed until the re-baseline is complete. However, aTAC continues to believe that staffing levels should be at least maintained if not augmented.*

a-TAC17 Answer to Charges

a1) Are there unaddressed technical issues in the main accelerator systems?

No. Nevertheless, the dump phosphor coating, the DTL coupler window, the medium- and high-β cryomodules, and Lindekryotechnik cold compressor issues should all be carefully followed.

a2) Is the schedule to complete manufacturing, testing and commissioning realistic? Proposals for mitigating technical and schedule risks would be highly appreciated.

A detailed schedule review is organized for May 22-24, 2018. Therefore the TAC is not asked to provide a detailed analysis of the overall time-line. But comments are in order.

The actual major re-baselining effort is based on significant schedule updates. Multiple delays are accounted for. The ESS installation planning team sees a clear critical path. Nevertheless, since some manufacturing contracts are still being prepared, a level of uncertainty remains. Further, the re-baselining requires sufficient in depth information from all in-kind partners. The regular update is a "must". Established project management tools for early warnings should be used and respected.

a-TAC17 Answer to Charges

a3) Comment on the new plan to install klystrons instead of IOTs for the first 44 cavities of the high beta linac. Is the decision properly motivated? Do you agree?

The new plan to install klystrons instead of IOTs for the first 44 cavities of the high beta linac is certainly well justified. It significantly reduces any associated risks with project planning, installation and operation. Further, it frees ESS from developing a new SML modulator design tailored to the IOTs.

The main motivation of IOT development is connected to its higher efficiency when compared to the klystron which operates at RF power level at 20% below saturation. The calculated savings in electricity bill is 7 GWhr/year. But this is offset by continued development costs and the estimated 70% higher series production costs for the new IOT technology.

a4) Comment on the continuation of IOT development with existing hardware to prepare for a decision after 2026 between IOTs and klystrons for the second half of the high beta linac. Do you agree or not? Why?

ESS has performed a service to the community with the MB-IOT development; and it is rare that such an opportunity comes to pass. But at this stage in the project, a continued active role in MB-IOT development would become a distraction.

If a new laboratory proponent steps forward to continue the development, ESS may consider to provide technical information and advice to them.

a-TAC General Findings

Findings

- A detailed schedule review is organized for May 22-24, 2018.
- Truly impressive work all over the site, especially in the accelerator infrastructure, was visible during the site tour. Pictures of many prototypes or even first series components under construction were presented.
- All in-kind contributors are working on last pre-production or first series components. The detailed status was presented during a poster session with representatives from the member laboratories of the ESS accelerator consortium. A-TAC appreciates the opportunity to see the posters and engage with IK partners.
- The ESS Accelerator Division line (and in-kind) organization was presented. Responsibilities for the coordination of overall installation in the three accelerator areas (tunnel, gallery and cryogenic buildings) are assigned by name.
- The ESS program of modulator development has been very successful. The in-house SML design out performs in specification and price and reliability.

a-TAC General Findings

Findings

- ESS is entering the first stage of accelerator components on site commissioning
- ESS presented a very comprehensive package of beam diagnostics; there is nothing missing.
- The committee commends the increased focus on integrating the various divisions, groups, and sections to work together to bring the new equipment online in a timely, safe, and efficient manner.
- A-TAC welcomes the focus on lessons learned, as there will inevitably be many such opportunities that should not be wasted.
- It appears that procedures and practices are either insufficiently developed or inadequately enforced for effective beam commissioning.

ESS re-baselining

Findings

- ESS is re-baselining the full project. An internal review of the accelerator sub-project was held in March and the comments from this review are now being implemented for the external review in the end of May. The proposed new Ready for Beam On Target (RBOT) date is 24 May 2021 with Beam On Dump (BOD) at 570 MeV 8 February 2021.
- The accelerator systems' critical path to RBOT goes through four intermediate milestones. All sub-projects on the critical path are observed including the near critical path ones (<60 days).
- ESS uses best estimates of delivery after careful consultation with in-kind partners.
- The optimization of the installation sequence in the tunnel and in the RF gallery is seen as the best tool for mitigating schedule delays. A large number of changes was implemented to gain time.
- A number of in-kind deliverables that presently are on the critical path are in the prototyping stage. Thus some technical risks remain which can easily convert into further delays. Nevertheless, ESS uses all actual knowledge for the schedule re-baselining.

Recommendation (response to charge a2)

- The ESS re-baselining requires sufficient in depth information from all in-kind partners. The regular update is a "must". Established project management tools for early warnings should be used and respected.

Schedule of Installation, Test and Commissioning

Findings

- Significant resources are being applied to the re-baseline; and this includes the planning and scheduling of "Install, Test, Commission" of the entire accelerator. Sophisticated scheduling and risk analysis is applied that includes "big picture" dependencies. Schedule risk is ranked by a matrix of criticality and float. The exercise is commendable.
- The actual major re-baselining effort is based on significant schedule updates. Multiple delays are accounted for. The ESS installation planning team sees a clear critical path. Nevertheless, since some manufacturing contracts are still being prepared, a certain level of uncertainty remains.
- Accelerator utilities installation is run by the infrastructure project. It matches the accelerator installation plan and is not on the critical path.
- TAC was told that a variety of manpower resources (in-kind, ESS, Skanska) would be applied to keep activities that are close to the critical path off the critical path. Ideally, in-kind resources should be applied proactively to make up previous delays and to re-introduce float into the re-baselined schedule.

Comments

- All in-kind contributors should be asked to update their delivery schedules as part of the re-baseline activity.
- There are strong inter-dependencies in the schedule. Nevertheless, equipment that has arrived should be installed when possible, reducing the later resource crunch. The detailed planning will facilitate this.

Accelerator & Installation

Findings

- There is impressive progress since TAC16 – the in-kind equipment (ion source, RFQ, DTL, etc) is beginning to become a reality. Hardware is starting to arrive in Lund.
- This marks the beginning of a new and challenging phase for the ESS project. The committee commends the increased focus on integrating the various divisions, groups, and sections to work together to bring the new equipment online in a timely, safe, and efficient manner.
- Beam physics applications are being developed in preparation for commissioning and operations, and they appear to be in good shape for this stage of the project.
- The ion source and LEBT section was delivered in December 2017. The tunnel installation makes good progress. The respective work allowed for first lessons-learned summaries.

Comment

- The coupler accident at the medium-β cryomodule test has led to the situation where series production has started before complete test of the prototype; this introduces uncertainty.

Beam Diagnostics

Findings

- ESS presented a very comprehensive package of beam diagnostics; there is nothing missing. The quantity and types of devices are commensurate with the power levels of the proton beam. Lessons learned from the ORNL SNS have been applied.
- Many beam instrumentation systems are in the final stages of fabrication. These systems appear to be in good shape for this stage of the project. Some compromises with the uTCA platform have been necessary.
- It is unclear whether the target phosphor coatings are sufficiently robust to survive prolonged exposure to the proton beam.
- Several of the devices (the current monitors, the ionization chambers, neutron monitors) will be used as inputs to the Machine Protection System and for loss accounting.

Comment

- The committee commends the increased involvement of ICS.

Recommendation

- Clarify the plan of how the three loss detection mechanisms will be progressively used to ensure the <1W/m loss rate will be achieved.

RF Systems

Findings

- A large part of the RF systems is provided in collaboration with partners. Many components are under procurement, RF distribution in the test installation phase, and installation of the RF reference distribution line is almost done.
- Modulator contracts are in place for NC and MB linacs. Klystron deliveries for the medium beta section is starting in June. Set-up of test stands at the ESS site has priority and is in progress. Installation of RF equipment in the gallery area is ongoing.
- Contracts are in place for the modulators (RFQ/DTL and medium beta). The procurement follows the ESS design (SML topology, 660 kVA).
- Congratulations on the ESS-designed SML modulator.
- Spoke RF stations and also magnet power converters are in the tendering process.
- Prototypes of the RF interlock systems exist. All systems are fully EPICS integrated.
- The LLRF system has been running in two test systems in Lund and two in Uppsala/FREIA since some time. The systems will be used for cavity tests in Sweden and also in France. Additional modules are being developed at in-kind partner labs. Procurement of first parts for the final version of the master oscillator has started.
- Prototyping and testing of RF equipment is using several test stands at Lund University, Uppsala, ESS Lund and at CERN.

Re-baseline IOTs and Modulators

Findings

- ESS has usefully employed the pre-installation phase of the project to perform development work on modulators and inductive output tubes (IOT) with a view to cost reductions and efficiency improvements. The original baseline foresaw to power the high-β cavities with IOTs.
- The investigation of modulator topologies has been extremely successful and conclusive in the SML design as setting a new standard for performance and price and reliability.
- IOTs offer somewhat higher efficiencies than klystrons in exchange for higher cost. The MW-level IOT design pursued by ESS with industry collaborators is almost unprecedented. Although the prototype is successful, the IOT design is not sufficiently mature for series production. The project must be pragmatic: move on to the procurement and installation phase of its RF power sources.
- The klystron production is split between two vendors to reduce risk; the two variants are socket compatible. The prototypes from both vendors satisfy the specification, with rather impressive efficiency bandwidth (in saturation).

Re-baseline IOTs and Modulators

Comment

- Coming 2026 when additional high-β modules are considered, the next generation high efficiency klystron technology, which could be ready in 2-3 years from now, could be considered as the advanced RF power source.

Recommendation

- Revising the baseline design to power the entire installed SRF linac with the same modulator and the same klystrons throughout will yield simplifications, schedule benefits, interchangeability and some immediate cost reduction due to the 70% lower capital cost of klystrons compared with IOTs and the successful SML modulator development.

Cryogenic & Vacuum

Findings

- Procurements are well advanced and significant installations are in hand.
- The cryogenic distribution system is the last cryo system to be installed for the accelerator, and is close to the critical path. If delayed, it could interfere with other installations in the tunnel - in particular, with the installation of the cryomodules. No overall installation scheme was shown in the presentations.
- The process controls for the accelerator refrigerator are based on PLCs programmed by Linde. The PLCs are already linked to some EPICS user interface, which can be used for the commissioning of the cryoplant

Comments

- A-TAC continues to believe that a single cryogenic and vacuum services provider to Accelerator, Moderator and Instruments is a good approach with strong "pay off".
- This existing EPICS cryogenic user interface needs to be integrated in the ESS EPICS process controls. The effort for this integration should not be underestimated.
- The Linde-supplied cold compressors have recently displayed shortened lifetime at DESY and FNAL. It will be prudent not to assume a vendor solution in the 2 year time frame.

Recommendation

- The activities of Linde Kryotechnik to fix the cold compressor issues should be carefully followed and observed.

Beam Readiness Review

Comments

- A-TAC is pleased that ESS now gives serious attention to prepare for readiness reviews. All aspects of readiness must be in place before readiness to commission can be claimed. Operation shall be safe for people AND for equipment.
- Document EHSAC_8 (Safety Readiness Review) was provided to the TAC. In general the scope and procedures are well thought and appropriate. We presume that "engineered controls" includes the list of interlocks. We agree that "safety" internal to the system belongs to the work package owner, and that the MPS and ICS groups should be responsible for implementing the interlocks. The proton beam connects systems together.

Recommendations

- Perform readiness reviews for all accelerator sections, without exception.
- A procedure should be identified to review the scope of MPS interlocks as they apply to damage that can be caused by the proton beam. Initially, limit this analysis to the obvious equipment fault or operator errors.

Lessons Learned

Findings

- A-TAC welcomes the focus on lessons learned, as there will inevitably be many such opportunities that should not be wasted.
- Lessons learnt from IS/LEBT installation emphasized the need for improved communication between ESS Lund and in-kind partners.
- Realizing that there are lessons to be learned from the IS/LEBT commissioning is the first step. The next step is to apply those lessons to develop, disseminate and establish new or better procedures.
- Technical compromises necessary during installation were reported. Wherever possible such compromises should be described in written form and communicated to all stakeholders.
- Based on the IS/LEBT test presentation, it appears that procedures and practices are insufficiently developed for effective beam commissioning.

Comments

- e-log: records "who did what, where and when"; typically also includes links to archival tools, screen grabs and so on.
- e-fault: communicates device names that must be fixed or repaired *quickly* by service groups. Commissioners should not have to wait. E-fault system also records equipment non-conformances including damage by operator error.

Lessons Learned

Recommendations

- Use of the e-log and e-fault shall be enforced. Test stands are not exempt. This e-log/e-fault must be accessible by IK partners off site.
- Without under-mining existing management structures, introduce a role akin to "head of commissioning" (HoC) for each accelerator section. This person should be ultimately responsible for the successful commissioning and operation of that portion. They are aided by a future machine operator who becomes familiar with routine tasks.
  - HoCs are the champion for and have a vested interest in the readiness review for a particular accelerator section; but they don't lead the installation.
  - HoCs have the authority to say "we commission to X kW today, but not higher"; they have the responsibility to ensure that equipment and people are safe when beam is operating. It must be clear to everyone, including IK partners, who is in charge.
  - Other management models also work.

Personnel Retention

Comment

- Design and commissioning are fun. Projects are fun. Staff must be retained after the project phase. The "head of commissioning by area" roles provide an opportunity to identify future leaders of operations and development groups and for individuals to commit to long-term engagement with ESS.
- One person should be assigned to each portion of the accelerator (e.g. Front End, warm linac, SCL, HEBT). This person should be ultimately responsible for the successful commissioning and operation of that portion, should be cognizant of the functions and performance limitations of the various technical equipment (vacuum, RF, water, alignment, controls, MPS, installation, etc.), should have a good understanding of the beam dynamics and equipment limitations, and should be capable of leading the commissioning effort. Later they may become the area coordinator.

Report on ICS at TAC17
11th -13th April 2018

Cyrille Berthe, Roland Mueller, Karen White and Mark Heron
(Co-Chair)

ICS Overall

Findings:

- ICS has made substantial progress since the last TAC, including installation of first systems, installation of infrastructure and operation of first control systems in ESS.
- Current scope of the ICS Division is clear in terms of software, electronics, infrastructure and integration.
- ICS Division is also clear in terms of scope of support for Accelerators, Target, NSS and CF.
- Since TAC15 ICS staff and contractors have increased from 32 and 11 to 52 and 17; with 4 unfilled positions.
- There remains great demand from other divisions for the available ICS resources, most notably for resources in the Hardware Integration Group.
- ICS is re-baselining based on a 2 year schedule delay.

ICS Overall

Comments:

- ICS staff are highly commended on their achievements.
- ICS Division has done very well to develop processes, support a wider range of subsystem developments and to start deploying its own infrastructure.
- Recruitment and development of the ICS Division is a major achievement. The cTAC believes ICS Division now has an appropriate number of engineers and technicians (in-post and in-budget) and an appropriate mix of in-house and contractors. However the project would benefits from a small increase in the number of engineers experienced in the EPICS software toolkit for the Hardware Integration Group.
- The committee feels that the ICS structure is fit for delivering ESS. In considering a proposed restructure there are opportunities to promote greater customer engagement and hence satisfaction.
- Developing and deploying the control systems on the accelerator in the coming years will put increased demands on ICS Division, while this needs to be planned for and the plans adhered to, there will demands that will have to been addressed in a pragmatic way to support overall project objectives.
- The presented cost increases from re-baselining are reasonable and to be expected.

ICS Overall

Recommendations:

- In considering the restructuring of the Hardware Integration Group ICS Management should think about how to ensure good customer engagement and the development of long term relationships between ICS staff and their customer groups.

ICS Target Control

Findings:

- Scope of the process control for the target has been identified.
- Life cycle for Target systems and the ICS are aligned, shared milestones are about to be agreed.
- Target controls integration team has with 4 engineers and 1 work package manager within ICS.
- Resources have been identified to do the integration work.
- The format of design documents is under development.
- Many PLCs are involved in the control of the target.
- The responsibility boundary is defined between ICS and Target.

ICS Target Control

Comments:

- Target and ICS significantly improved understanding of the scope of work and communications. Both groups identified gaps.
- There is strong interdependence between the two groups who will need to work closely together through each phase of the project.
- Both groups should take into account the safety aspects that will impact the success of project.
- Take advantage of factory acceptance tests and test benches to validate equipment and software at each phases of control system development. The periods of calibration and ongoing maintenance should be included in the design

ICS NSS Controls

Findings:

- ICS in a first phase concentrates on generic controls across all instruments (chopper, motion, etc.). ICS control system software stack and environment are a must and will be available.
- ICS are aware that some instrument specific controls for complex systems (robots, etc.) will be requested.
- ICS expects and properly states that sample environment will be by far the largest source of unique equipment.

ICS NSS Controls

Comments:

- ICS team members are working to address needs for generic instrument technology controls.
- Team members assigned to NSS controls are not sufficient in number to cover fundamental equipment (choppers, motion, detectors, etc.)
- Sample environment is identified as a source of large number of specific and diverse devices.
- The interface to the user control system (NICOS) and the DMSC requirements is very complex and might become complicated.

Recommendations:

- Complete the local vertical integration project, continue to elaborate on demonstration (V20) and testing (lab instrument beamline) capabilities.

ICS Software

Findings:

- The selected software CS-Studio tools have been deployed to the temporary control room and used to test cryogenics facility and are available for ion source testing.
- Configuration tools including CCDB, CDB, Naming Service and RBAC are in use.
- Software tools for Operation Sequencer, Software Interlocks and Post Mortem Analysis have been requested but are not part of the ICS baseline

ICS Software

Comments:

- The Software Group has delivered the essential set of tools needed for initial operations, however, development work will continue to enhance these tools.
- Most operational tools require significant configuration where the parameters must be determined by system owners; work to develop these configurations will likely continue through machine commissioning.
- The planned training for ESS staff should help to develop a shared understanding for what is necessary to develop good display, alarm and archive configurations.
- The Software Group has prioritized their work to ensure the most critical operational tools are in place early as hardware becomes available.
- The group should explore existing tools for the Operations Sequencer function and managing commissioning (ie eLog and for fault recording).
- The term "Software Interlock" should be reconsidered as true interlocks imply a high level of integrity which is not necessarily available from software. The described function of this tools is not really an interlock but more an interlock trip avoidance tool.

ICS Control System Infrastructure, Installation experience, and Commissioning Plans

Findings:

- Control system Infrastructure appears to be state of the art in all aspects: network topology, physical and functional segmentation and installation support tools.
- The group takes advantage of virtualization and container capabilities. They are well aware of the caveats to be respected in the real time environment of controls.
- Human factors and ergonomic analysis have been considered in the design of the ESS Main Control Room.
- The ESS network is divided in three parts :Technical Network, General Purpose Network, Neutron Data Network
- The ICS standard MicroTCA platform being delivered as an IK agreement, has suffered delays from contractual and technical difficulties. An alternate platform is now being pursued for several beam instrumentation systems.
- The MPS has not yet been deployed for the ion source test stand.

ICS Control System Infrastructure, Installation experience, and Commissioning Plans

Comments:

- The infrastructure team is very capable and has adopted appropriate tools for efficient delivery of the network.
- Additional consideration to cyber security should be planned to ensure access to the ICS is appropriately controlled.
- The choice of the high performance controls uTCA platform is a key decision for ESS with implication for technical functionality, ongoing support and risk.
- The ICS Protection Group should deploy an appropriate segment of the MPS for the ion source teststand and subsequent machine sectors as installed. This is an excellent opportunity to demonstrate the MPS architecture and characterize the system while ensuring the machine is protected as it is installed.

ICS Control System Infrastructure, Installation experience, and Commissioning Plans

Recommendations:

- Division Heads for Accelerator and ICS need to conduct and oversee an internal review of IOXOS platform for all BI systems. Out of which a decision should be made and documented setting out the hardware platform of choice for each subsystem and all parties should move forward on that basis.
- The Infrastructure Group should consider implementing single sign-on access all ESS systems and help to develop ESS-wide cyber security policies.

Have the recommendations and concerns expressed by c-TAC16 been addressed adequately?

- Yes. Underlying structures in CHESS and ICS configuration tools have been streamlined. Tools seem to be made available, more functions are about to come.

Charge Questions (1)

c1) Concerning ICS organization:

- *Is the competence mix appropriate for the coming project phases?*

Yes.

- *Is the employee/consultant balance appropriate?*

Yes.

- *Is the organization properly adapted for a transition to Initial Operations?*

Yes.

Charge Questions (2)

c2) Concerning the planning for NSS controls integration:

- *Is the prioritization of deliveries from ICS to NSS technologies groups appropriate?*

Yes, given the time available.

- *Is the balance between workload and available resources cost-efficient for integration?*

Yes, however the Hardware Integration team may need some additional resource.

Charge Questions (3)

c3) Concerning the handover of control systems infrastructure:

- *Is the strategy for connecting devices to the technical network clear and well communicated?*

Yes.

- *Is the plan for using virtual machines for IOC well defined?*

Yes.

The plans are well aligned to common best practices, so the technical network will scale to the needs. The proper balance of single purpose and hosting hardware, as well as server and service platforms will adjust as the project proceeds. Additional planning is needed for cyber security and access control considerations. The plan for virtual machines is sound.

Charge Questions (4)

c4) Concerning accelerator controls:

- *How do we best migrate to a single hardware standard?*

See recommendation.

- *Comment upon the foreseen interfaces between ICS and Accelerator for the different systems. What are the risks? Would a change of interfaces now save/cost money/schedule?*

See recommendation, this need to come form an internal assessment.

Charge Questions (5)

c5) Concerning ICS software readiness for initial operations

- *Is the selection of software components appropriate for transfer into Initial operations?*

Yes, the essential tools are available now and feature development continues

- *Is the plan for staff transfer into initial operations consistent with the stakeholder's needs in this phase?*

This is unclear as transfer plans and stakeholder needs were not presented

Report of t-TAC17
11-13 April 2018

Tim Broome, Michael Butzek, Phillip Ferguson (Chair), Masatoshi Futakawa, Jürgen Neuhaus, Szabina Török, Jörg Welte

t-TAC general

- The committee believe the bunker has difficulties that might benefit from external advice. t-TAC recommends that the bunker become part of its purview.
- The Active Handling Cell program appears to have cost and schedule issues. High priority should be given to this task.
- The target schedule has slipped ~12 months due to funding issues in Spain
  - Although not on the critical path, finding ways to improve the schedule is encouraged
- Contingency in the schedule up to BOT should be considered, particularly in light of the re-baselining activity.

Concerning Process controls and joint plan with ICS

Findings

- The integration strategy that accounts for installation, verification and validation of the integrated system has been presented for the target system. The NSS systems have not been taken into account in a similar way so far.
- ICS has recently assigned four staff and one project manager to developing and implementing the control systems for the target station.
- The full scale deployment of EPICS 7 and MicroTCA4 ensures a future-proof scenario. The layered architecture for the ESS control system is appropriate and has been proven by other research centers.
- Actual ICS Organization structure was presented. Beside the topical groups dedicated core teams (e.g. for Target) have been formed.
- ICS seems to be well staffed.
- ICS recognizes that information exchange between hardware and cooling/utility process engineers and control engineers is very important.
- Cable routes are the responsibility of target systems within the target building.

Concerning Process controls and joint plan with ICS (cont.)

Comments

- The available staff should be appropriate to have specific margins and a flexible approach in order to control progress and handle unforeseen events for the integration plans at an appropriate level of detail. Consideration should be given to identifying what is essential versus what would be nice to have.
- Information exchange between hardware engineers and cooling/utility process engineers and control engineers is very important to start early in the design phase and continue until FAT and SAT. Joint milestones and common design reviews are a great way of ensuring that the hardware, cooling/utility processes, and controls are well integrated for all areas, including instruments.
- The need to ensure that only qualified staff are able to change Target Station operating conditions is understood but the mechanism for achieving this is not yet settled.
- Implementing a dedicated Target Core team, including a focus on operations, is a good action
- Make sure flow of information between in-kind partners supplying components and systems and ICS is properly coordinated.

Concerning Process controls and joint plan with ICS (cont.)

Recommendations

- **In light of the rebaselining activity, some thought needs to be given to appropriate resource levels with Target and ICS**
- **Given the level of staffing, controls support for NSS must be increased as soon as possible**
- **Increase integration of controls in mechanical hardware and cooling/utility process systems detailed design process as early as possible**

Concerning Target monolith and instrument bunker interface

Findings

- A feasibly concept design of the Light Shutter System (LSS) and a principal concept of the Insert Exchange Tool (IET) were presented
- An alternate concept was presented that removed the BBG windows, but complicated handling of the light shutter
- The instrument bunker interface was not presented this time.
- The light shutter system for shielding gamma-rays from activated components ensures the appropriate dose level for ongoing installation of additional instruments after first beam on target as well as for maintenance during routine operation.
- The aluminum windows on each end of the bridge beam guide (BBG) are ~1 mm thick
- There are expected, eventually, to be 80 to 90 choppers in the bunkers.
- With an expected maintenance cycle of five years, this means that approximately five choppers will need to be replaced in every shutdown
- The area close to the monolith is expected to get sufficiently active that 'hands-on' maintenance will not be possible.
- The only access to the bunker areas is through the roof

Concerning Target monolith and instrument bunker interface

Comments

- Omitting the BBG would complicate component handling in the bunker, especially instrument installation work after initial operations
- Estimates of the reduction in source brightness for a 1-mm thick Al 6061 window are ~1-2%
- Minor improvements on the neutron extraction systems should be avoided in favor of simpler, robust and already advanced solutions.
- It is likely that the whole bunker area will be contaminated. Methods to control the spread of this contamination are required.
- Consider more range of movement for the light shutter open position. Rather than fixed 'open' switches consider having a device to measure the position (e.g. a potentiometer) which would allow the experimental teams to fine tune the position of the BBG.If personnel entry to the area of the bunker near the monolith becomes impossible, installation of new beam lines in these areas will have to be done remotely
- The radiation dose rates in the bunker areas must be monitored carefully and, if necessary, the proton beam power limited so that the strategy for maintenance is not compromised.
- Its not clear how does the Area access control Systems work together with the Shutter Control System. This especially in the maintenance phase.

Concerning Target monolith and instrument bunker interface

Recommendations

- **The committee recommends that the bridge beam guide be retained**
- **Explore reducing the thickness of the BBG windows**
- **Engineering controls, including cables, locks, etc., should be used for the access system in the bunker**

Concerning Waste management and the Active Cells Facility

Findings

- The Active Cell Facility is large relative to other similar facilities
- Environmental code has set a maximum value of 550 tons of Radioactive Waste to be stored at the ESS site
- ~30 tons of rad waste may be generated at ESS during an operation year

Comments

- No matter how large the cell is, it will never be big enough
- Use local shielding to reduce dose rates from active components in the cell
- A uniform approach across the project to waste planning, including the use or non-use of the active cell, needs to be considered. A resource may be required to work with engineers to find solutions.
- Ensure as far as is practical that equipment and services in the active cells can be maintained remotely in case entry of personnel turns out to be not possible
- ES&H views the active cell as the route for any waste with dose rate >10 mSv/hr. How does this impact the linac beam dump?
- Emergency recovery plans should be developed to recover from a tool getting stuck, etc., in worst case scenarios
- Tritium will be absorbed into steel surfaces. Consider tritium releasing during cutting processes.

Concerning Waste management and the Active Cells Facility

Recommendations

- **The committee recommends that a workshop be organized quickly where relevant experts from existing facilities (e.g., JPARC, SNS, and PSI) can meet with ESS and RACE staff to share their experiences and provide feedback on cell designs**
- **There will be active handling activities in accelerator, target station and NSS. The committee recommends that an 'Active Handling' working group be set up at an appropriate time to coordinate active handling activities and promote a common approach both in methods and equipment.**

Concerning Worker Radiation Safety Strategy and Policy

Findings

- An approach to handling public and worker radiation safety separately was presented
- An implementation plan has been developed and is being executed

Comments

- Excellent progress to a system which is consistent with best practice at other facilities
- In normal operations including maintenance activities, evaluate the dose rate and use that information to develop appropriate procedures

Recommendations

- **ESS is encouraged to proceed with the presented strategy**

Concerning TOAST experimental results and impact on licensing

Findings

- Tungsten release fraction experiments have been completed in collaboration with experts in the field
- Results are consistent with other estimates/experiments

Comments

- Some conservatism still exists in the current analysis
- Postulated event is very unlikely if not impossible
- Higher ARF does not greatly increase the offsite dose

Recommendations

- **Adopt the TOAST results and complete the safety analysis**

Have the recommendations and concerns expressed by t-TAC16 been addressed adequately?

From TAC16, Focused effort on the bunker should be a priority is still a valid concern. We recommend:

1) Increased effort on the bunker
2) An update on bunker design and procurement at TAC18

Annex 1

Agenda TAC#17 April 11-13, 2018
ESS, Tunavägen 24, Lund

	11 April -18
11:45	Shuttle from Elite Hotel Ideon
12:00	Light Lunch - TAC Members only - Ljusgården
	TAC Closed Session
	Tänkartanken
13:00	TAC Initial working session - TAC Members only
	Plenary Session
	Tänkartanken
13:30	Welcome and overall status of ESS - J Womersley
14:00	Charge and Organization of meeting -R Garoby
14:20	*Coffee - Ljusgården*
14:45	Accelerator - M Lindroos
15:30	Target - M Anthony
16:15	ICS - H Carling
17:00	TAC Working session - TAC Members only Tänkartanken and Scheele
18:30	Transportation to Dinner
19:00	*Social Dinner - *By invitation only* - På Skissernas, Finngatan 2, Lund*
21:30	Shuttle to Elite Hotel Ideon

	12 April -18		
07:45	Shuttle from Elite Hotel Ideon		
	BrightnESS		
08:00	Safety induction and Site walk - TAC Members only		
09:30	Shuttle to ESS Tunavägen		
	Conference Area 203		
10:00	*Coffee - Conference Area 203*		
	Joint, and parallel sessions		
	Accelerator - Christinehof	**ICS - Lilla Tuna**	**Target - Stora Tuna**
10:20	Beam Physics (Commissioning prep.) and beam instrumentation - A Jansson	Introductions and Agenda Review/Committee Charge - H Carling	Introductions and Agenda Review/Committee Charge - M
10:45	RF Systems and specialised power supplies - A Sunesson	Process controls and Joint plan with ICS - T Friedrich	
11:10	Cryogenics and vacuum - J Weisend		
11:20		ICS Organization update - H Carling	Target Monolith and instrument bunker interface - J Koning, R Linander
11:35	Accelerating structures - H Danared		
11:50		Software readiness for Initial Operations - S Regnell	
11:55			Process on Waste management and the Active Cells Facility. - P Jacobsson ESH and M Göhran
12:00	Installation test and commissioning plan - C Plostinar		
12:30	*Lunch - Inspira *By invitation only**		
	Klystrons or IOT for first 10cm in HB Linac		
13:30	Status of the ESS MB IOT Developments – Review of the	Planning for NSS controls integration - J Sparger	Worker Radiation Safety Stategy and Policy - L Coney and P Jacobsson
14:00	prototype test results and comparisons		TOAST Experimental results and impact on licensing - P Nilsson
14:10	Modulators for IOT and klystrons - C Martins	Handover of control systems infrastructure - R Mudingay	
14:30	Lessons learnt during Front End preparation and installation - W Ledda, T Shea		Helium filter design and remote maintenance concept - U Odén
15:00	ICS/ Accelerator plan for commissoning - A Jansson, H Carling		*Coffee*
15:30	*Coffee*		**tTAC Working session**
	Accelerator - Christinehof	**ICS - Lilla Tuna**	**Target - Stora Tuna**
16:00	**aTAC Working session**	**cTAC Working session**	**tTAC Working session**
17:30	Accelerator Poster sessison - Ljusgården		
19:30	Shuttle to Elite hotel Ideon - TAC Members only		
20:00	*TAC Dinner at hotel - TAC Members only*		

	13 April -18		
08:15	Shuttle from Elite Hotel Ideon		
	TAC Closed Session		
	Accelerator - Stora Tuna	**ICS - Kronovall**	**Target - Lilla Tuna**
08:30	**TAC Working sessions**		
10:30	*Coffee*		
12:30	TAC Lunch at Hyllan- Inspira		
13:45	Close out - Tänkartanken - Will be streamed		
14:30	End of meeting		

Annex 2

Charge to the TAC for its 17th meeting on April 11-13, 2018

1. Introduction

The ESS construction project is now more than 43% complete, as visible with the progress in Conventional Facilities, with the amount of equipment delivered on site and with the advances in installation.

The ion source and LEBT from INFN Catania are typical examples. The system is now in place in the tunnel as the first part of the accelerator beam line, and installation of the support equipment in the Front End building is actively progressing although at a slightly slower pace than initially foreseen. Lessons have been learnt and a new organization is being set-up for installation of utilities.

As the delivery timescale for the target building (the critical path for the whole ESS project) is now much clearer as well as the delayed delivery dates of multiple in-kind contributions, a schedule re-baselining exercise is underway which will be reviewed by external experts in May 2018. Our goal is to minimize any impact on the high-level goals of starting initial operations in 2019 and user science programme in 2023.

During the different sessions of this meeting, detailed status and plan will be provided to the committee for Accelerator, Target and ICS subprojects. In addition, posters prepared by in-kind partners will complement the information on the Accelerator.

2. Charge questions

The following questions to the Committee address present concerns of the different subprojects:

- for the **Accelerator**:

a1) Are there unaddressed technical issues in the main accelerator systems?

a2) Is the schedule to complete manufacturing, testing and commissioning realistic? Proposals for mitigating technical and schedule risks would be highly appreciated.

a3) Comment on the new plan to install klystrons instead of IOTs for the first 44 cavities of the high beta linac. Is the decision properly motivated? Do you agree?

a4) Comment on the continuation of IOT development with existing hardware to prepare for a decision after 2026 between IOTs and klystrons for the second half of the high beta linac. Do you agree or not? Why?

- for the **Target**:

t1) Concerning Process controls and joint plan with ICS:

- *Is there a clear integration strategy that accounts for installation, verification and validation of the integrated system?*
- *Do integration plans have specific margins and a flexible approach in order to control progress and handle unforeseen events?*
- *Are integration activities planned and performed at an appropriate level of detail?*
- *Are the available people, tools and procedures sufficient and appropriate to support the foreseen integration activities?*

t2) Concerning Target monolith and instrument bunker interface:

- *Does the design satisfy the functional and performance requirements?*
- *Are the Radiological Safety Aspects adequately addressed?*
- *Are the Operation and Maintenance sequences for Port Inserts adequate?*

t3) Concerning Waste management and the Active Cells Facility:

- *Is the ESS approach to waste management robust and thorough*
- *Is the current division of responsibility sound?*
- *Do you recommend changing some interfaces?*
- *Would a change of interfaces now save/cost money/schedule?*

t4) Concerning Worker Radiation Safety Strategy and Policy:

- *Is the current strategy and policy for worker radiation safety appropriate and reasonable?*
- *Is the risk matrix for radiation hazards for workers in reasonable balance to other conventional hazards?*
- *Are the defined dose limits for workers appropriate?*
- *Are the ESS General Safety Objectives, classification methodology for disciplines, PSAR coherent with regards to worker safety?*

t5) Concerning TOAST experimental results and impact on licensing:

- *Is the response to the higher ARF adequately addressed?*
- *Are the changes to AA3 sufficiently supported and justified?*
- *Are the existing SSC's being credited properly?*

t6) Concerning Helium filter:

- *Does the helium filter design seem adequate?*
- *Is the approach for remote maintenance of helium filters sound and appropriate?*

- for the **Integrated Control System (ICS):**

c1) Concerning ICS organization:

- *Is the competence mix appropriate for the coming project phases?*
- *Is the employee/consultant balance appropriate?*
- *Is the organization properly adapted for a transition to Initial Operations?*

c2) Concerning the planning for NSS controls integration:

- *Is the prioritization of deliveries from ICS to NSS technologies groups appropriate?*
- *Is the balance between workload and available resources cost-efficient for integration?*

c3) Concerning the handover of control systems infrastructure:

- *Is the strategy for connecting devices to the technical network clear and well communicated?*
- *Is the plan for using virtual machines for IOC well defined?*

c4) Concerning accelerator controls:

- *How do we best migrate to a single hardware standard?*
- *Comment upon the foreseen interfaces between ICS and Accelerator for the different systems. What are the risks? Would a change of interfaces now save/cost money/schedule?*

The Committee is encouraged to provide also suggestions/comments and recommendations on any other subject it would find relevant. Feedback on the follow-up of former TAC recommendations is welcome.

A preliminary version of the TAC report is expected during the close-out session in the afternoon of Friday 13, April. The final report is expected before the end of April. The Chairman will orally present the TAC#17 report to the ESS Council on June 4-5.