ESS Technical Advisory Committee
Summary Report of the 15th Meeting
Lund, 5-7 April 2017

A. Facco for the ESS-TAC

General TAC15

- Meeting
  - well organized
  - Charges to Committee clearly set
  - Very good quality of presentations
  - All relevant meeting documents made available to Committee in advance, including answers and comments to recommendations of TAC14

- The Committee thanks ESS for the warm hospitality

General TAC15 - Project status

Findings:

- Impressive advancement in the conventional construction
- In-kind deliveries on site have started
- installation of cryogenic and electrical systems started
- Prototyping of critical components successfully progressing
- Progress in staff recruiting and internal organization
- Increased effort in reinforcing the interaction with IK contributors
  - To prevent or limit delays in delivery
  - To early transfer knowledge and ownership
- Focus on not exceeding the planned cost ceiling and schedule
  - Value engineering exercise
  - Partial and temporary Re-scoping to 1.3 GeV, while confirming the ESS mission
- Progress in standardization, quality control, integrated installation planning.

Comments:

- The Committee commends ESS team for the continuous effort and the impressive progress achieved in the project

- Main concerns
  - Delays from the baseline schedule
  - Costs increase from baseline in some procurements
  - Technical solutions not finalized yet in some critical items

General concerns from the Committee [1/5]

- Tuning Beam Dump
  - The Committee is concerned about the present status of the TBD. The present, preliminary design can accept a maximum beam energy per pulse of 12.5 kJ, only 3.5% of the specified value for the ESS beam on Target. As a consequence, the standard procedure of tuning an accelerator with nominal pulse current and time length, at a reduced repetition rate, on the TBD before sending it to the target will not be possible. The final accelerator tuning to reach the nominal pulse length will have to be performed with the beam already on target. This will likely represent a source of increased difficulties in the linac operation, with possible negative consequences which have not been fully clarified yet.
  - Ways to mitigate this problem have been shown, but a robust and fully motivated baseline plan was not finalized yet.

Recommendation:

- All implications on machine operation and safety, related to the reduced power capabilities of the tuning beam dump, should be deeply investigated as soon as possible. A reliable tuning procedure should be defined, including critical details, before the ESS Initial Operations Review in May 3-5 2017.

General concerns from the Committee [2/5]

- IK contributors delays
  - Concern is raised by the delays in the procurement which are impacting the installation schedule. In several cases this is caused by administrative problems on the IK contributors' side which delay the finalization of the procurement contracts.
  - The ESS team is taking appropriate actions to mitigate this problem, but a delay of several (likely about 6) months on the final beam delivery date is to be expected and should be reflected in the schedule.
  - The Committee agrees that a new integrated plan for installation must be developed based on reasonable estimates of the real RFI dates, and that the whole schedule must be rebaselined as soon as the procurement contracts will be officially signed.
  - It is good to see Target Division resolving identified in-kind contributions without a partner. There is still 5 MEuro left; keep working the issue.

General concerns from the Committee [3/5]

- Installation plan
  - A well advanced integrated installation plan has been presented by STS, which is however strongly success oriented, with minimum or negligible float. This makes very difficult to accomodate even small changes in components delivery dates from industry and IK contributors without generating conflicts impacting the overall schedule.
  - The Committee is concerned about additional possible delays that can be expected in the planned installation schedule.

General concerns from the Committee [4/5]

- Value engineering exercise
  - A thorough value engineering exercise is being performed, resulting in a valuable amount of resources made available, at the cost of a limited and temporary modification of the project scope.
    - Savings: 11.818 MEuro
    - Deferral: 27.818 MEuro
    - Total Cost Reduction - 39.636 MEuro
  - The necessary value engineering actions should preserve the planned local infrastructures for maintenance, testing and possible R&D. Some cleaning/reprocessing/testing capability, both in know-how and infrastructures, is needed in a large facility like ESS to cope with possible incidents (e.g. vacuum incidents) and restore operation in a predictable time.

General concerns from the Committee [5/5]

- 1.3 GeV, 3 MW option
  - The Committee supports the decision of limiting to 1.3 GeV the beam energy at full current by suspending the procurement of the RF of 10 High beta cryomodules. It represents a good solution, which gives ESS a still outstanding scientific scope while leaving it open to the future achievement of the final 2 GeV goal with minimum changes in the project and with minimum cost increase.
  - If compatible with having beam on target in the planned time, the possibility of installing anyhow the extra cryomodules in the linac, although in the absence of RF power sources, should be considered since it would significantly facilitate the final upgrade to 2 GeV.
  - Before taking this decision, a comprehensive study should be made to clarify if and how EM modes excitation of the unpowered extra cavities installed, potentially causing beam loss, could be reliably prevented.

General charge question

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

Generally Yes.

Proposed topics for TAC16

- Resonators and cryomodules prototyping update
- Tuning Beam Dump reference operation plan

Report of a-TAC15
5-7 April 2017

Frank Gerigk (Chair), Shane Koscielniak, Alban Mosnier,
Bernd Petersen, Hans Weise, Paul Cruikshank

General Comments

Findings

- Impressive progress on civil engineering, e.g. tunnel, gallery, and compressor building ready to receive equipment.
- Applying additional contractor resources (1.5 shift and double shift) to keep civil construction on track, and to catch up with delays at the target building.
- Significant progress on the source (1.8x smaller emittance), medium beta cavities and CM, and modulator development. The procurement of vital commercial components is gaining speed (cryogenic equipment, klystrons, ..).
- Delays of 3-6 months appeared because of halted IK packages, technical or administrational issues, so that the schedule contingency of 6 months (Dec 2019 instead of mid-2019) has disappeared. Installation work is being parallelized to save time.

General Comments

Comments

- The committee appreciates and encourages the continued operation of the RF integration test stand in Lund, the start of test at the FREIA test stand and the preparations for the CM test stand in the ESS gallery.
- The high-level schedule still shows RFI milestones which definitively cannot be reached, but will be updated thanks to an integrated schedule, including installation, testing and commissioning which will be soon available.
- The present delays in the prototyping/early delivery phase indicate that further delays should be expected.
- It was not clear how the impact of de-scoping across the WPs is handled and how the subsequent changes on the installation scope or schedule are organised.
- We consider that the 30 month installation tsunami is under-resourced. Volume of work will be challenging to coordinate.
- Has the MB-IOT exercise become a distraction? (different modulator, different pre-amp)
- Most of the QA/QC is performed by contributors/companies due to lack of local staff/time/expertise. Choose a number of key items to be repeated in-house.

General Comments

Recommendations

- Parallelized installation work can result in non-safe working conditions. A completed PSS must be in place suitable for the divided building space, so that schedule pressure does not impact safety.
- The committee has concerns about the dual limitations of the tuning beam dump (average and peak beam power) and recommends to study a beam tune-up and commissioning scenario that works with a limited peak power dump to verify if this scenario is viable (see general recommendations).
- We recommend to establish as soon as possible the capability for small interventions on the CM (e.g. coupler exchange, pick-up exchange, repair of feed-throughs, tuner ..). A complete module assembly infrastructure is not required. Nevertheless, once the series assembly infrastructure is no longer available, the possibility for a disassembly down to the removal of the space frame should be foreseen.
- Some local capability for UHV and particle-free cleaning should be foreseen.
- Even with qualified companies and sub-contractors the manufacturing & installation schedule of the cryo-distribution system seems unrealistic. The production capacities of the involved sub-contractors and in-kind contributors should be verified. Pre-series valve boxes should be sufficiently cold tested before start of the full production. A strong supervision of subcontractors and in-kind contributions is recommended.

Have the recommendations and concerns expressed by a-TAC14 been addressed adequately? [1]

The recommendations of a-TAC14 have largely been addressed. The points, which were not fully clear are:

- We appreciate that ESS staff is starting to spend time at in-kind contributors & suppliers (e.g. vacuum staff at STFC, MB-IOT, etc). This effort should be ramped up.
- The documentation effort is commendable but the effort of checking documentation and follow-up on inconsistencies may be under estimated.
- Reviewers are still uncomfortable with control of the RFQ water cooling circuit.
- Reviewers are still uncertain whether the coordination of multiple LLRF efforts has been strengthened.

The detailed answers, which were given to the a-TAC14 recommendations are listed on the following pages.

Accelerator Topics for TAC15 and A-TAC15 answers to charges

a1) Are there any significant technical issues seen in the STS work?

- The concept of smoke detectors / fire extinguishing should be discussed. Are there local detectors for early detection? CO2 or similar systems? Please avoid Sprinkler systems!
- It is not fully clear if the operating pressure of the target monolith atmosphere can be achieved.

a2) Is there any orphaned scope identified?

- It does not seem to be clear what power can or needs to be taken by the beam dump to ensure efficient beam commissioning.
- Some work packages for which no in-kind contributor has been found need to be insourced in order to keep the schedule.

a3) Are the interfaces between the STS work and other work packages properly defined and addressed?

- Process not finished yet. The Cabling Data Base concept sounds convincing but experience shows that the task is quite challenging. Includes work with procurement experts.
- It was not clear if agreed change requests are distributed quickly enough to the concerned work packages.

a4) Are there any issues seen in the STS work as it transitions from project construction to operations?

- More experienced staff is required for commissioning and first operation of cryogenics.
- Issues will come… better QA/QC results in less surprises… for whatever reason, cabling is often the critical path during construction; also because expert installers are difficult to find. Cables can be installed before and after equipment installation. Use both time slots accept no compromises!
- Make sure an adequate safety and access system is in place for both periods, especially when installation and commissioning takes place in parallel.
- A rigid coordination is needed to have parallel activities in the tunnel.

Accelerator Topics for TAC15 and A-TAC15 answer to charges

a5) Comment upon the risks and options for improving the proposed solution for an initially reduced beam power of 3 MW.

- The deferral of RF systems for the last 10 HB cryomodules would allow the saving of 28 M€. A further 12 M€ could be saved through value engineering.
- We support the plan to finish the complete accelerator cryo-module supply and installation. An early module assembly stop poses a huge risk of loosing the resources at in-kind partners. Replacing it by local ESS Lund resources will not work, even though a complete knowledge transfer to Lund has to take place.

a6) Do you see any significant increase in total project cost, up through and including the installation of deferred components, and, in that case, can you suggest mitigations?

- The foreseen / hired / well trained operation team can supervise / carry out the later installation. This even saves additional money. But make sure the knowledge is transferred. Otherwise additional project cost will arise from keeping the expertise at the partner institutes. Unless they can be ‘contracted’ with sustained R&D efforts (XFEL/DESY model).

a7) Do you consider the presented solution for the RFQ cooling circuit adequate, and does it remove the concerns formulated at the TAC meeting one year ago?

- The simulations appear to show that the system is tunable, even when the pump & mixing valve are not close to the RFQ. However, placing the pump & mixing valve at a significant distance from the RFQ (large loop delay) will make for difficult tuning of loop gain parameters, as will cross-talk between the circuits.
- Moving the valve closer to the RFQ would certainly ease the tuning.

a8) additional question: Should the high-b CMs be installed, even if they are not powered during the first year(s) of operation (de-scoping exercise)

- A late installation would mean to send people into an already activated tunnel. Lengthy installation work would be difficult under these circumstances.
- Installing the modules immediately has the risk of activating the modules before they accelerate beam. This will anyhow happen to all installed modules.
- We see a certain preference to keep these passive modules cold.

Proposed topics for TAC16

- What areas of expertise are still missing at ESS for commissioning & operation? (e.g. exchange of warm part of coupler, CM disassembly, …)
- Report on cold linac progress, in particular: i) test of first CM, ii) spoke, low- and high-beta tests.
- Report on beam dump choice and associated commissioning scenario.
- Equipment Commissioning Readiness (coordination & verification)
- Mitigations for delayed/orphaned IK WPs
- Mitigations for installation tsunami
- Plan for con-current pre-operation, installation and commissioning in 2020-2023
- Survey and alignment

Report on ICS at TAC15
5 - 7 April 2017

Cyrille Berthe, Roland Mueller, Karen White and Mark Heron

General Findings

- ICS has continued to make substantial progress in past 6 months.
- Current scope of the ICS Division is clear in terms of software, electronics, infrastructure and integration. An Operations review has clarified ongoing scope of the division and required resource level going forward.
- A major re-plan has been completed which has refined the budget and defined the work associated with ICS installation.
- Since TAC14 ICS staff and contractors have increased from 29 and 6 to 37 and 11. The number of open positions has reduced from 10 to 5. There is still great demand on the available resource.
- ICS IK contracts have been agreed, and while short of their initial target are now at an acceptable level.

General Comments

- Deploying the controls systems on the accelerator in the coming year will put increased demands on ICS Division.
- ICS still lacks sufficient experienced engineers to meet the ESS project milestones; recruitment of staff and on site contract effort should continue to be aggressively pursued.
- ICS delivery is at risk due to delays in setting up the IK hardware agreement.
- There remains some uncertainty over ICS's scope of support of control systems for Neutron Instruments.
- While the ICS approach to EPICS 7 stands to deliver a control system with advanced capabilities, careful prioritization is needed to ensure this does not negatively impact resources available for integration work.

Digital Platform and FBIS Findings

- Three hardware platforms have been selected based on signal speed. With new developments being invested in MCTA for reasons of longevity, interoperability and maintainability.
- Development of a software/firmware stack from hardware to EPICS is in progress.
- An architecture and structure for realisation of the FBIS has been defined.
- There have been delays setting up the IK agreement for processor cards. This was partially, mitigated by self funding early design activities with the intended supplier. ICS has developed strategies to mitigate late availability of hardware.
- ICS has agreed a way of working with customer groups whereby ICS provide the software/firmware framework and the customer groups develop their IP within the framework and hand back to ICS for deployment.

Digital Platform and FBIS Comments

- Choice and structure of MTCA hardware is well thought out. Standard hardware should now be purchased in quantity to issue to technical groups who need it.
- The development of the software/firmware stack is progressing but should be released early, with an initial feature set, to enable customer groups to work with it.
- Good progress has been made on the FBIS. In moving forward, bear in mind the inherent benefits coming from simple solutions.
- Delays in setting up the IK agreements for MTCA hardware have delayed the availability of hardware to support ICS's customer groups and are causing concerns for ICS's customer groups. An approach may have to be taken to deliver some early systems on non standard hardware to meet programme, and subsequently upgrade. However ICS should work closely with technical groups to minimise this as subsequent migration will be very difficult to achieve.
- Technical groups have some well advanced applications on non standard platforms. ICS needs to provide substantial effort to support technical groups in migrating their applications onto the standard hardware platform.

Software and Applications. Findings

- ICS has committed to full scale deployment of EPICS 7. By that ICS is taking a leading role in EPICS developments.
- Global community support and maturity of EPICS V3 allows ICS to provide pragmatic and powerful solutions at day one.
- On the other hand ICS is well positioned to take advantage of novel capabilities of EPICS V4.
- Flagging ICS base environment EPICS 7 shows the ICS commitment to invest in the EPICS V4 developments thus inspiring possible collaborators to add forces.

Software and Applications. Findings

- OpenXAL is a well adapted and in good shape for high level software tools.
- OpenXAL has been significantly extended by ESS in modelling functionality and usability.
- Already available pilot applications inspire confidence.
- The planned suite of application covers a reasonable list and to a large extend, applications are already available.

Software and Applications: Comments

- The plan to use EPICS 7 seems reasonable as it allows the project to leverage the considerable base of device support written for V3 while also taking advantage of new V4 features where appropriate.
- To support the use of EPICS 7, ICS should update the ESS naming protocol to include guidance for naming composite PVs.
- ICS' ambitious approach to automation of control system configuration has the potential to become exemplary for other projects.
- Data sources, like Python readouts of instruments, that are initially outside the EPICS world and may be integrated into EPICS at a later stage. These data have to be integrated into ICS at some level, but not necessarily via EPICS V4 right from the start.

Installation Planning Findings

- The replanning of ICS project during 2016 revealed that there was a lack of consideration for the installation. It resulted in identifying installation activities and costs.
- The planning activity considered the installation and combined it with the commissioning phase.
- Work packages are clearly identified but there remain building dependencies in relation to the utilities. There remains risk of delay in the definition of requirements of some systems.
- A staged approach to initial-operations show the need and the difficulty of installation work in terms of organisation, which has revealed many parallel tasks.
- ICS re-planning estimated a need for additional budget on installation activities.
- Importantly issues in managing quality work have been defined.

Installation Planning Comments

- Good progress has been made in refreshing the ICS plan and adding details for installation
- There still appears to be a need to manage the project cable requirements (ICS part) with their detailed specifications (connectors, fire resistance, type of cables, EMC).
- Consider benefits from software tools can help manage the installation through 3D modelling, diagram software, software to calculate the paths.
- Consider to establish a broad framework contract managing project installation; provide the substantial resources required.

Recommendations

- ICS should make standard hardware solutions and support framework available to all customers at the earliest opportunity; to minimise further developments on non-standard hardware. Intermediate solutions which are the same architecture as the final solution would help facilitate this.
- The current phasing of instrument construction implies a considerable peak in workload for ICS which will be difficult to manage. Scope of support from ICS and phasing of neutron instruments should be reviewed.

ICS Response to TAC 14 Recommendations

- Recommendations from TAC14 have been fully addressed.

Charge Questions (1)

c1) Are technical choices for the MTCA platform appropriate and sufficient?

Yes, they well reflect today's level of standardisation.

c2) Have the major technical obstacles for deploying the digital platform been identified and addressed?

Technical obstacles, are understood and are being managed. There remain logistical obstacles in terms of availability of hardware and resource to support.

c3) Are the features of EPICS 7 addressing the needs of the facility and are they ready for deployment and operation at ESS/ICS?

Yes, as long as EPICS 7 stands for a pragmatic and well balanced initial setup and development path of the components EPICS V3 and EPICS V4.

Charge Questions (2)

c4) Will the planned development, testing, and approval procedures allow for sufficiently high quality to ensure reliable operation?

The committee needs to see more detailed information in this area to make an informed judgement.

c5) Have all the major installation activities for commissioning and operation been identified and their needs addressed?

Yes, major installation activities have been identified at a high level. However, precursor activities do not appear to be taking place to facilitate this.

c6) Is the relative priority and ordering of tasks appropriate and reasonable considering the commissioning/operation plans?

The committee needs to see more detailed plan to make an informed judgement.

Report of t-TAC15
5-7 April 2017

Michael Butzek, Phillip Ferguson (Chair), Masatoshi Futakawa, Jurgen Neuhaus, Szabina Török

T-TAC general

- As usual, the hospitality was exceptional. Thank you!
- The Target Division and in-kind partners were well prepared and we appreciate the open exchanges.
- The t-TAC14 recommendations were all addressed, or progress is being made.

- Suggested topics for t-TAC16
  - An update on the beam dump design
  - An update on the QA plan for manufacturing hardware
  - An update on the instrument bunker design

Is the presented design of the tuning beam dump sufficiently robust and versatile?

- **Findings**
  - The current tuning beam dump can meet the PDR requirement of 12.5 kJ, 12.5 kW for a 1 minute average. Some cooling is required.
  - The requirement of 358 kJ can not be met by the current design.

- **Comments**
  - There was some confusion as to the dump requirements. The desires now appear to be clear. The question will be what is really needed versus what can be afforded in cost and schedule.
  - It is clear that no one believes a 5 MW beam dump is a reasonable and affordable solution. Full power tuning to the target may be the solution, but it needs to be studied and agreed upon.

- **Recommendations**
  - **<u>Work with Accelerator Division to understand what is really needed, then develop a cost and schedule for a beam dump concept that can meet that requirement.</u>**
    - Look for alternative options along the way...

Comment on the decision not to pursue a windowless solution with differential vacuum pumping between the monolith and the accelerator, at this point in time.

- **Findings**
  - A decision was made to preserve the capability to have a proton beam window, consistent with the t-TAC14 recommendation.
  - Multiple scenarios, involving air and helium atmospheres were analyzed.
- **Comments**
  - The committee is concerned about nitric acid attack of not only the neutron guides, but also the steel shielding inside the vessel. This is compounded in off-normal scenarios with water leaks, etc.
  - Isolating the neutron guides from potential nitric acid with thin windows is a good idea and protects that investment at relatively low loss of neutron brightness.
- **Recommendations**
  - **Complete the analysis, remembering that "off-normal" events like water leaks are typically not "off-normal".**

Is the process for identifying and allocating safety functions sufficiently comprehensive and balanced in order to assure a reliable and safe operation of the target station?

- **Findings**
  - A target station radiological hazard and accident analysis was presented.
  - Qualitative analysis of active cell facility utility area and monitor area were shown.
  - Safety functions were defined.

- **Comments**
  - The approach is comprehensive and has substantially progressed over the last year.

- **Recommendations**
  - **<u>Complete the analysis with a quantitative assessment and extend the analysis for maintenance activities and non-rad workers.</u>**

Is the presented approach for definition of the “ready for beam” signal sound and well balanced? Are all relevant process parameters selected with appropriate thresholds?

- **Findings**
  - Development of the process is underway and seems promising.
  - Further investigation of the relationship between target station systems and beam configurations is needed.

- **Comments**
  - Need to further define operating parameters to arrive at parameter threshold values.
  - Next level: Target “ready for beam” is also dependent on beam restarts: after long shutdowns (maintenance with moving shielding blocks), a long beam trip, etc. This may require radiation surveys to make sure shielding has been returned to correct location.

- **Recommendations**
  - **Continue to work with ICS and accelerator, to define what signals are passed and when.**

The committee is asked to give...recommendations with respect to transition from final design to manufacturing.

- **Findings**
  - The ESS process of PDR, CDR, FAT, and SAT, are well thought out.

- **Comments**
  - Manufacturing of parts is beginning without final decision from licensing authorities. This is a risk that parts may have to be re-made, etc.
  - Accredited body should be involved early enough in the process, if needed.

- **Recommendations**
  - **<u>Work to understand what accredited body needs to be involved at what time in the design, manufacturing, and delivery process.</u>**

Comment on the chosen technical solutions for the neutron beam extraction system and the instrument bunker.

- **Findings**
  - The neutron beam extraction system is in a design and construction phase, but it is not clear that the handling of radioactive components is complete and has all necessary information.
    - Need more info on radiation fields, which will impact the required level of remote operations versus hands on activities.
  - Substantial progress has been made in the detailed design of the bunker shielding issues.
- **Comments**
  - There is a non-negligible risk in not using gaskets for the neutron beam window.
  - Optimization of the bunker design has to be done considering cost and handling.
- **Recommendations**
  - **Look for increased involvement of an experienced beamline engineer in the design process to insure needs are being met.**
  - **Seek increased involvement of the neutron optics group in the design of the neutron extraction system to make sure their needs are met.**