2016 Annual Review of the European Spallation Source Final Report

GENERAL IMPRESSION

- Once more a very intense and positive year, impressive progress since spring 2015.
- The ESS project is now accelerating its path, the Civil Engineering work is in full swing, the accelerator begins to deliver its first hardware.
- Every subproject is making detailed plans for the installation, which should start this autumn for the accelerator.
- About 21% of the entire project cost figure has been already spent. In-kind projects have started.
- The 2019 milestone to deliver a first beam on target remains a challenge.
- The ESS is starting to emerge out of the green field, it has the initial ingredients of a real host laboratory within the ERIC framework.
- Operation resources and planning are now the next steps in the project definition.

TABLE OF CONTENT **PAGE**

LIST OF APPENDICES

TOP 10 ACTIONS

1) Level 1 Technical Coordination, Communication, Integration: The ESS technical coordination scheme is helping to facilitate the technical integration risks, however the committee finds there is still a need for technical ownership of the entire ESS facility. Reconsider the need for a TC or DDG at Level 1.

2) Installation schedule (steering, organization, …): Related to action #1, remains a need for an overall technical coordination of ESS to manage the installation activities, as well as coordination of the allocation of space and logistics.

3) ESS liquidity: ESS will run out of cash by the end of 2016, even if all the approved contributions are received as planned. It is absolutely essential to prepare for a final decision at the June Council meeting. Solutions exist.

4) VAT, taxation and employment conditions for in-kind partners @ ESS: The ESS ERIC Agreement provides VAT tax exemption for its in-kind partners, however the specific implementation plan for VAT exemption in each country are not in place. This uncertainty is a high risk of schedule delay (upcoming in-kind contracts). ESS should work closely with the ERIC in-kind partner representatives to resolve this as soon as possible.

5) In-kind organization: Although some 50% of expected TAS (235) are agreed or in preparation, the Committee remains concerned about the local follow up and progress with respect to set schedules and milestones. The Committee is pleased to see the EC-funded Brightness project offering tracking and assistance for its regional hub partners, but does not consider it sufficient. The Committee thus recommends a stronger presence of ESS staff at IK partner production locations, in particular in the early phases of the agreement execution.

6) 7-12 months projected delay: As this reported delay has a fundamental impact on other projects, the Committee recommends that under the leadership of ESS management, a thorough analysis is made resulting in a resources loaded schedule, with the necessary interfaces identified. The updated baseline plan needs to reflect the phasing of the work, realistic staffing, funding profile and clearly identify areas where scope reduction could provide tangible contingency. The advice is to re-baseline the overall schedule, focusing on delivering science in 2023 and incorporating consistent contingency provisions (“float”).

7) NSS construction agreements and schedule: There are serious doubts that the budget plan for 16 instruments is feasible within the 350 M€. Thus the NSS should descope instruments to fit within its budget. This must be done in a way that does not significantly affect initial scientific capabilities. Performance should be prioritized rather than the number of instruments. Furthermore, the Committee recommends that the NSS develop a detailed plan for multiple simultaneous installations in the

bunker that will involve reviewing the readiness and priority for the initial instrument suite. Urgency should be given to establish all pending agreements.

8) Regulatory permits: ESS management is encouraged to increase its current interactions with SSM to avoid the absence of required permits causing delays in the construction, installation schedules and start of operation.

9) Bunker story: The bunker design, requirements and construction are on the critical path. Thus the NSS must move aggressively to produce a detailed design of the bunker and to have it manufactured and installed. This will require much more interaction between the various parties in the different projects. Waiting for an in-kind parter for this item looks unrealistic and a possible source of problems and delays.

10) Risks analysis and financial implications: The risk register appears to contain items which are entered inconsistently across the different projects. The software-calculated value is not well understood. It is recommended that once the baseline cost and forecast variances are available, consistent guidelines are followed across the projects to update the registry and to identify risks that established contingency allocation mechanisms will not be able to cover.

1. SUBCOMMITTEE 1: ACCELERATOR

1.1. Progress since last review

- Good progress has been made in virtually all areas since the last review. We believe all of our previous year‘s recommendations have been implemented and we were told that these actions were beneficial so far.
- The Blinky Light test was a success and should be extended.
- As previously recommended, the division has been reorganised and the structure is now much better suited to executing such a large scale science project.
- New IK coordinator at Division HQ level.
- Linac group reorganized.
- The AD Safety group leader is empowered and effective.
- Engineering Resources group created to plan hardware installation.
- Some of the teams have started to get their „hands dirty“, which is essential as installation and commissioning gets ever closer.
- The schedule has been much improved since the last review although it remains extremely challenging and completely success oriented.
- The ESS team has initiated beam-commissioning planning.
- Reduction of hot water for Klystron cooling to a safer 60 degrees level.
- A well-established review process for all critical IK systems and documentation of their specifications in technical annexes.
- Review and documentation in DOORS of the (large number of) interfaces.
- QA/QC process has been established, mainly for IK contributions.

1.2. Findings

- The IK partners from INFN, CEA, CNRS, and STFC have all reported excellent progress toward project goals. Each partner feels an ownership for their deliverables and schedule, but acknowledges strong pressure to stay on schedule. In several cases, the IK partners have to “cut corners” to achieve the schedule.
- The poster session for IK partners was a success and has been extremely useful for detailed information to the committee and direct contact with the responsible persons.

1.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

Yes, as far we are able to tell the plans are adequately mature and detailed.

An important effort has been made to complete the design reviews, in order to converge on a final design in most of the critical items. The scopes are well defined, the requirements are specified in detail and a follow-up and verification is foreseen.

QA/QC tools are in place.

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

Yes.

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

The scheduling has improved since the last review with much more detail in the installation schedule. There is a general agreement that the schedule is aggressive and is based on the "success" approach. Some margin exists but the risk is rather high and an alternate approach could be considered to get a more realistic scenario.

In order to respect the present schedule, some IK partners had already to "cut corners". That could result in an inconsistent approach of the various accelerator systems with the risk of scope or performance reduction of some systems and possibly the whole accelerator.

No plan B and spare resources at the central project level to compensate for any problem (technical or financial) in the critical IK work packages that will inevitably happen.

No time is foreseen in the schedule to take into account the results of prototyping and tests in the series production.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

The ESS teams are interacting well with all the in kind contributors who are working towards the schedule milestones. However most of the TAs still remain unsigned.

The schedule pressure on IK partners is aparent and may compromise quality of deliverables.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

The transition from the construction Phase to Operation is not well defined, the matching between budget/time is not appropriate and the personnel could be a potential problem.

1.6 Are project risks identified, updated, and risk responses relevant and complete?

Risks and associated costs are identified but the mitigation often involves cutting short development or testing in order to meet the schedule and does not allow to take into account the result of tests.

1.7 Does the organization match the needs of the construction project?

Yes, since reorganisation the division is now well suited to delivering the project.

1.10 Are the Safety, Health and Environment and Quality Assurance functions being properly addressed at the project's current stage of development?

The QA/QC function is well advanced, especially when it comes to IK contributions. It is not obvious if it is being practised internally, for example when AD interacts with ICS. Some areas of HS&E are being addressed but there remains much still to be done to install the safety culture.

1.4. Critical issues

- There is a great focus on achieving the milestone of first beam/neutrons in 2019 and there is a danger of this overiding the long term goal of a reliable and sustainable facility due to 'cutting corners'. It may be time to review the timing of this milestone.

- There is no provision for spares in the construction budget as this is considered to be part of operations. This leaves the facility vulnerable to 'infant mortality' and accidental damage during installation and commissioning.

- Progressn the ICS is lagging behind progress in other areas. If this is not addressed hardware will start to arive with no adequate or consistent means to control it.

1.5. In-kind status

- In-kind partners were well represented at the review. Good progress is being made across the board with all partners well focussed on the project schedule and milestones.

- The majority of TAs and contracts remain unsigned although there is optimism that most will be addressed in the coming year. However this does not appear to be hindering progress with any of the contributors.

- The issue of VAT remains for some contributors.

1.6. Actions

1. Use the existing test stands and areas to integrate the activities across divisions and to spread the safety culture.

2. Extend the “Get your hands dirty“ experience to other areas, for example:

   Diagnostics

   Realistic tunnel section mock-up

   Follow-up Blinky Light Test.

3. Send your staff (to the extent possible) to learn and to train on IK deliverables, for example, the Ion Source at INFN Catania.

4. Start defining the strategy on spares and equipment repairs/upgrades.

5. Evaluate the need for a local Ion Source test stand.to

6. Continue your effort to involve universities in the ESS project. This will help in training staff for future operations.

7. Continue to refine beam loss scenarios from both safety and machine protection aspects. Evaluate a „worst case“ scenario of beam losses and corresponding activation along the accelerator. Review if the beam losses management, collimators & shielding design and machine protection systems are appropriate to mitigate the activation and avoid remote handling maintenance as much as possible.

8. Encourage the use of same project management tools across divisions.

2. SUBCOMMITTEE 2: TARGET SYSTEM

2.1. Progress since last review:

- The subcommittee commends the project for an overall good progress made since the last review. The target system team has been stable and competent and strong in-kind partners are on board and integrated. Additional personnel needs have been identified (installation and interface management) and a first recruitment been made. The change in leadership from John Haines to former deputy Eric Pitcher has been a smooth transition.

- The design of the target wheel is mature, there has been no significant design change since a year. In-kind partner ESS-Bilbao has made good progress towards the manufacturing of the target wheel: early thermo-mechanical studies have been validated by more detailed studies, a target wheel section has been fabricated and its construction improved, first tests on the release of dust from the target have been made. A set of vendors for suitable tungsten has been identified based on material studies.

- With regard to the moderator reflector system a major schedule concern at last year’s review has been resolved. FZ Jülich has been recruited as IKP and is fully engaged and on track: a first one-to-one prototype has already been built and

pressure tested and the purchase of the hydrogen cryogenic system is imminent. The engineering reality of the prototype is close to the neutronics design. Verification of the thin-moderator concept with tests at J-PARC has been successful.

- Good progress has been made in target controls. The team is in place and working. The design of the target safety system seems to be well integrated and a pilot PDR has been held. Important progress has also been made in evaluating accident scenarios to support PSAR for licensing application.

- With regard to remote handling a critical design review was performed for parts of the active cells confinement work. A competent in-kind partner (UKAEA (RACE)) was found for the active cells work and a kick-off meeting was held. Communication between the remote handling and IKPs for the target wheel and moderator/reflector is in place.

- For the monolith system overall good progress has been made by ESS-Bilbao in the design of the vessel. Manufacturing and transportation aspects are included in the design, structural analysis supports reducing the wall thickness, neutronics calculations support choice of elastomers for the seal material. Progress on the proton beam window includes the study of a water-cooled system in response to the request for an increased window thickness. Preliminary design of the tuning beam dump has started. The ESS target team has developed a viable concept for the handing of the neutron beam port insert.

- With regard to the fluid systems good progress has been made by completing preliminary designs for water-cooling systems, the target station HVAC and the helium purification system. Hazard and operability studies for these systems have started. UJF has been identified as the in-kind partner for the primary and intermediate water-systems and for the target HVAC system.

- The target physics group has made the transition to supporting design, licensing, and operation planning as recommended at the last review.

- With regard to installation planning and management a knowledgeable person is on board and developing the detailed installation schedule for the target facility.

2.2. Findings

- Recommendations have been overall appropriately addressed. Some recommendations need further follow-up:

  - Although a dedicated diagnostics beam port has been chosen, the scope remains to be defined.

  - An overall commissioning plan for the target station appears only to be in place up to the point of first beam on target.

- Conversation with CFID exposed a 9 months delay. The target group has recovered 2 months by optimizing the target systems installation schedule.

- The installation schedule under development has good level of detail for an individual system. No float is included to account for unforeseen delays. We noted that target system installation is serial and does not leave room for changing installation logic. Multiple critical paths can lead to delays.

- We did not see how target installation schedule integrates into overall ESS wide installation schedule.

- Communication with IKPs appears to be working well and the ESS target team and partners come across as an integrated team. Cross-division communication seems to be less developed.

- Many ICDs are still to be completed. A non-standardized format is the current situation.

- Activation and contamination of target fluid and helium system will occur and have significant impact on operation and maintenance. The committee is concerned whether this is sufficiently considered in the design.

- The committee noted that the choice of single or two helium re-circulators for the target cooling was unclear.

- The vacuum level defined for the vessel has been changed from rough to high vacuum. Achieving high vacuum appears complex given the size of the vessels and the equipment inside and pump down times are uncertain.

- The committee is concerned about the generation of dust from the target and its significant impact on operations. Initial investigation into dust have started and generation of dust was observed in 1g tests. It is not clear if this is a representative test.

- The committee notes that instruments views on moderators are fixed.

- No handling of liquids in the active cell is foreseen, which if required would significantly impact the hot-cell design. The current design of the active cells does also not foresee the handling of dust. Lifetimes of electronics components in the active cell is uncertain but under study.

- The committee noted that the beam dump has maximum limits defined. ICS must ensure that these limits will not be exceeded.

- The committee notes that the engineering communication between NSS and target needs to be strengthened.

- The presently identified target station cost increase is unlikely to reduce – installation cost is uncertain.

- Consider pooling installation cost and coordination across facility (e.g. wiring, piping, cleaning, documenting, etc.).
- We were not presented with an ESS wide integrated plan for transition to operations.
- We noted that multiple critical system rely on a single partner (ESS-Bilbao) with a single key-person.

2.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

The scope of work for the target system is fully defined. Plans include all activities necessary to deliver scope. Critical ICDs and requirement docs need to be completed in a timely fashion. Design reviews and planned reviews appear appropriate. Verification activities have occurred. Future verification activities are not fully defined (e.g. dust, operations).

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

An EAC has been prepared, but is yet to be used as a management tool.

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

The target schedule is tracked and managed well but not integrated within the overall ESS project schedule yet. Target completion is currently later than the ESS project schedule date for external beam on target.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

IKPs are managed and integrated well. 79% placed or identified. ESS has been proactive in enabling long-lead time items.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

The plan for transition from the construction into initial operation is being worked on but far from complete. Target facility key performance parameters are still being developed.

1.6 Are project risks identified, updated, and risk responses relevant and complete?

The target team identifies, updates and manages technical and in-kind partner risks well. Management of cross-divisional risks is less apparent (example: schedule change, orphan scope).

1.7 Does the organization match the needs of the construction project?

Yes. The target team seems appropriate, stable and very competent and matches the needs of the present design and construction phase of the project. Looking forward we note that the target team has limited depth of operational experience.

2.4. Critical issues

- The development of an integrated installation schedule across ESS (e.g. including CF and NSS bunker).
- Improving communication across divisions.
- Commit to operational reviews for fluid systems including target helium cooling system.
- Understand consequence of activated dust in helium loop. Ensure design does not generate dust. Ensure operation can cope when dust is produced.

2.5. In-kind status

- Target systems have continued to follow a very clear map of IKCs with release dates and of the scope of work.
- The IKPs on board appear committed, competent, and integrated into the ESS target team.
- In total 22 in-kind work elements are in place, partners have been secured for 79% of in-kind scope.
  - Partners have been selected for 16 IKC packages, 2 packages have been released but no partner yet, and 4 packages have still to be released. Those still open include the monolith shielding (Euros 15M) which is on the critical path.
- Achieving the target of 90% of in-kind contributions appears realistic and the team is prepared to self-perform the remaining work.
- Difficulties were articulated with regard to the development of TAs: sign-off “is never-ending battle”. Defining IK requirements as design progresses makes this a moving target.

2.6. Actions

1. Continue to develop the installation schedule across ESS (e.g. include CF and NSS bunker) and develop intermediate milestones across ESS divisions.
2. Drive the improvement of communication across divisions.

3. Operational reviews are needed either as part or prior to CDR for fluid systems including target helium cooling system.

4. Decide on having 2 helium re-circulators for facility availability.

5. Review the feasibility of achieving 10^{-5} mbar in fully equipped monolith vessel and the operational impact of necessary pump down time.

6. Understand consequence of activated dust in helium loop. Ensure design does not generate dust. Ensure operation can cope when dust is produced. Consider existing spallation source data (Laser Doppler Vibrometer data from J-PARC and SNS).

7. Insist in ESS wide coordination of installation and commissioning, ESS wide review of time and money required for both.

8. Assess impact of single-point failure of key-people leaving the project.

3. SUBCOMMITTEE 3: INTEGRATED CONTROL SYSTEMS

3.1. Progress since last review

- Nine new employees have been recruited into the ICS Division.
- Four out of seven members of the ICS management team have been employed.
- The ICS schedule has been redeveloped.
- ICS governance has been established.
- The model for delivering the ICS has moved to being based on in-house resource.
- Personnel Safety System design is developed.
- Infrastructure design is developed.

3.2. Findings

- Good progress has been made with most of the previous recommendations. However, two recommendations remain to be realised.
  - The control system handbook has not been completed and issued. There is a draft in progress and information does exist on a Wiki but is incomplete and has not to been communicated internally or to partners.
  - The recommendation to develop interface control documentation has made some progress, but there are difficulties in bringing out requirements from other divisions. This is further compounded in that some of these requirements will come from IK partners, prime contractors or sub-contractors, do not exist or are not readily available.

- The development of ICS Division since the last review is impressive. There is an appropriate structure, best practice management strategy and good progress in recruiting needed resources. However, the division still lacks some depth of control system experience.

- The model for delivering the control system has changed from being largely contracted out, to realisation by an in-house team and IK partners. Albeit supported by contract effort. This is in-line with accepted practice and maintains knowledge in-house and so presents a lower risk to the ESS project.

- Re-planning appears to have been done with a high level of quality, but work remains to complete the plan. While it is important to complete development of the detailed ICS schedule, this must proceed in parallel with an accelerated effort on near term technical deliverables.

- ICS needs to establish a deeper understanding of what is really required from the Software Group versus tools and features that are desired and could be provided later.

- The ICS project plan is being developed based on a bottom up approach, to address major deficiencies in the current top down plan. This is informing the overall project plan, risk and EAC.

- Excellent progress has been made with the Personnel Safety System for the Accelerator and this is well aligned to the overall project schedule.

- Three hardware standards (PLC, EtherCAT, and MTCA) have been established and align with system requirements. The low and medium speed platforms are proven COTS solutions and are considered low risk. The high-speed digital platform (MTCA) is under development with in kind partners and is based on a very similar VME module. The first article is due to be delivered in October 2016 and there is some uncertainty about meeting this deadline. A fall back position has been identified that would also meet customer requirements.

- Infrastructure including the Control Room design study, networking, switches, and servers are in good shape on schedule and budget.

- The focus of software development is on the development of a central configuration databases in order to standardize data and process for local control systems. This development is far from complete. The basic required software infrastructure such as version and selection of EPICS core, alarming, archiving, HMI is not easily identifiable, available, deployable and exportable.

- A standard development process (naming conventions, repository, packaging, delivery, installation, etc.) is not clearly communicated. The current draft of the ICS handbook is not complete.

- Majority of ICS staff do not have practical experience in the EPICS environment or in developing, installing, testing and integrating control system for experimental facilities. EPICS training and getting the hands dirty in real projects needs to be pursued aggressively.

3.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

The scope of work is adequately defined, however given the time available the scope should be limited to what is needed to deliver to the overall project schedule. At present the development of the ICS plan means that all activities are not captured. This will be addressed in the near future.

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

An EAC has been prepared but given that the ICS schedule in still in development then the level of uncertainty within the EAC will potentially exceed the additional work identified. The update of the schedule will address this.

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

No, schedule is currently being developed.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

Only a limited amount of IK deliverables have been identified. Some further IK may be possible but the 50% target looks unrealistic. The procurement looks to be in good order.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

A first assessment has taken place but work and details analysis need to be undertaken. This is compounded by a lack of Operation Group.

1.6 Are project risks identified, updated, and risk responses relevant and complete?

Yes.

1.7 Does the organization match the needs of the construction project?

The ICS organisation structure matches the needs of construction project but there is inadequate experience and numbers of control system integrators.

3.4. Critical issues

- Cross division communications in ESS appears to be deficient at times.
- ICS software is on the critical path, “minimal scope” has to be identified and hard prioritization is required.

3.5. In-Kind status

- Since last review the target for IK contribution has been redefined as 50% of budget. Assessment of potential IK partners has at best identified 25% and it appears unclear if the 50% is credible.
- The ESS project needs to take a view whether delivering the ICS IK target or delivering the control system to schedule with cash is more important.

3.6. Actions

1. The ICS division needs to recognise that ESS project is schedule limited. ICS management must define a minimum set of objectives for the control system schedule; and develop the new schedule around this. This needs to be focused on the delivering the core control system, system integration and minimum applications to run the Accelerator, Target and Instruments.
2. Schedule EPICS and ESS development environment training on a period basis for ICS staff, ESS staff, IK partners and organisations delivering control systems.
3. Document and release the ICS handbook. Apply and validate it internally on early projects, e.g. first CF project. Then communicate it to external project, e.g. proton source Catania.
4. ICS needs to hire additional staff to meet proposed schedules and should recruit individuals with demonstrated experience, developing similar controls systems, at large experimental user facilities.
5. The ICS Division must install the standard ESS control system on the RF test stand as soon as possible to provide a realistic test of a controls vertical slice with a variety of hardware and provide staff an opportunity to interact with tools.
6. As test stands are established, some outside of the ESS labs, cyber security hazards must be assessed and managed.

4. SUBCOMMITTEE 4: NEUTRON SCATTERING SYSTEMS

4.1. Progress since last review

- Fifteen instruments have been selected for inclusion in the construction phase of the ESS with 2 options for a 16th instrument.

- In-kind partners have been assigned to lead 14 instrument projects – ESS leads one. In-kind contributions have been assigned for more than 50% of the budget and will likely exceed 60%. 93% of expected in-kind contributions have been identified. The remaining 7% is being used as contingency to be assigned later.

- The NSS has initiated a process to reduce the scope of their activities to match the budget of 350 M€.

- NSS is aware of some of the key challenges associated with interfaces between NSS and other organizations within the ESS and with their external partners. Thus they are working on service level agreements within the ESS and they have created many standards documents to allow in-kind partners to build instruments to the same standards.

- Andreas Schreyer has replaced Dimitri Argyriou as Director of NSS, Shane Kennedy has become NSS project leader. Dimitri Argyriou is now Head of Operations planning.

- Hot commissioning of instruments has been scheduled closer to the start of the user program in 2023 rather than first neutrons in 2019 in response to a previous recommendation.

- Work on the neutron guide bunker has commenced and NSS now has a conceptual design that may satisfy radiological requirements.

4.2. Findings

- Fifteen instruments have been identified as part of the construction project. In-kind partners have been engaged for 14 of these instruments. The in-kind partners are a strength of the project as constructing this number of instruments on the time-scale of the project would be impossible for any single organization.

- The instruments identified for inclusion in day one user operations (2023) are reasonable and have the endorsement of the Scientific Advisory Committee.

- De-scoping the initial instruments to fit within the available NSS budget has the potential to significantly impact the early scientific success of ESS.

- The current NSS contingency is 7.1% which is likely insufficient. Steps are being taken to re-evaluate currently planned scope with a move to increase this to 8.7%. However, the goal should be 10% at this stage of the project. In addition the budget

of the fourteen instruments being built by partners will each contain a 10% contingency managed by the partner.

- Over the next year, NSS is transitioning from project planning to project execution. However, detailed planning, particularly for NSS technical support groups awaits the final definition of the instruments scope, which should be completed in 2016.

- NSS has identified “orphan scope" associated with vacuum systems.

- NSS has been successful in attracting external funding for neutron technique and technology development and data analysis software. This has allowed them to supplement their activities.

- There has been significant progress over the past year to address safety within NSS and some clarity has been obtained, for example, in regard to establishing radiological zones in the instrument areas. In addition, a lot of effort appears to be connected with applying for the next SSM license. However, there is a need for a more coherent, project-wide, integrated approach to establishing a safety culture that moves beyond radiological hazards.

4.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

Yes, however, the scope does not fit within the 350 M€ budget. During the rest of this year NSS must work to reduce scope by about 60 M€. This issue is well recognized by NSS and they have begun interacting with potential in-kind partners to descope the first instruments to reduce costs. In addition, it is essential that they review all of the technical functions funded within NSS to see what can be reduced or delayed. This process should take into account the requirements of the first instruments and by prioritizing early scientific success. Even with these measures it is highly unlikely that NSS and their partners can deliver 16 instruments with appropriate scientific capabilities within their budget. While descoping is necessary, it is imperative that the instruments deliver world-class science.

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

Yes, but it really is an empty exercise for NSS as the budget is “ring-fenced.” This means they have a fixed amount of money to spend (350 M€) and they must adjust scope to meet the target.

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

No, as most of the instruments will be built by in-kind partners and the scope of these instruments is still not settled. This makes it impossible to make a meaningful schedule. NSS understands the urgency of reaching agreement on these instruments and has a process in

place to settle on the scope of the instrument suite by the end of the year. Thus they should be able to produce a reasonable schedule in the first half of 2017.

Even more urgent is the design of the bunker. This is an NSS responsibility that sits at critical interfaces between NSS and the target and conventional facilities and between NSS and its in-kind partners. The lack of a detailed bunker design and schedule is now causing issues for the target and will soon be an issue for partners who are delivering instruments. This MUST be the highest priority for NSS in the coming months

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

Planning is far advanced for the initial complement of instruments at the ESS. There has been an extensive process to develop and review instrument proposals. This has resulted in a compelling initial suite of neutron instrumentation. And while there are few formal agreements for instrument delivery in-place, work is on going. NSS understands the need to make final decisions on scope and has developed a path forward that should result in final decisions on instrument scope by the end of 2016.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

The scope of the instruments to be delivered is still not set. Thus the installation of the instruments and the transition to initial operations is not completely clear. The one crucial milestone for NSS is the start of user operations in 2023. We believe that this schedule, while aggressive, can be met.

1.6 Are project risks identified, updated, and risk responses relevant and complete?

Yes, but the NSS should pay more attention to developing risk mitigation strategies.

1.7 Does the organization match the needs of the construction project?

Yes, with the exception of some critical engineering hires. There is also a credible plan as to how the organizational structure can be evolved as the ESS transitions from a project to an operating facility.

4.4. Critical issues

- The design, fabrication, and installation of the bunker is a major task on the critical path of the ESS. At this point, there is only a conceptual design of the bunker with a set of calculations that show it to be radiologically sound meaning that it would meet Swedish radiation safety requirements. While the person who did the shielding calculations is very capable, given the complexity and importance of the bunker, an independent review is required. In the current simulations, the floor has been loaded to its limit. There would seem to be limited scope for additional shielding. This situation must be urgently addressed and a sound solution developed

that includes a verified radiological design, a detailed engineering design, fabrication, and installation.

- The NSS budget is fixed at 350 M€. It is clear that the currently planned scope would cost over 400 M€. Thus NSS must move urgently to reduce the scope to fit within its budget. This process should include all activities of NSS including both instrumentation and scientific support services. Care must be taken so that the reduction in scope does not significantly affect initial scientific capabilities. NSS should work to better understand the cost of the bunker and other shielding.

4.5. In-kind status

- The in-kind partners have the skills and experience necessary to deliver outstanding neutron instruments. Most of the formal agreements have yet to be finalized as the instrument scope has yet to be decided, though work is ongoing.

- In-kind contributions have been assigned for more than 50% of the 350 M€ NSS budget with another 35 M€ identified. This is ≈93% of target IK contribution of 227.5 M€. The remaining 7% is being held as contingency. This is an excellent achievement. However, the construction of the bunker is included in the 93% and detailed design has not yet begun, though contacts have been made with four potential in-kind partners.

- Improved communication is necessary between the instrument group and in-kind contributors in order to achieve standardization to the greatest possible extent and to ensure that there is no duplication or orphaned scope.

4.6. Actions

1. The NSS must move aggressively to produce a detailed design of the bunker and to have it manufactured and installed. This is beyond urgent.

2. The NSS must descope instruments to fit within its budget. This must be done in a way that does not significantly affect initial scientific capabilities. Performance should be prioritized over the number of instruments. In addition, NSS must descope scientific support by setting clear priorities for all aspects of these activities including sample environment, laboratories, and DMSC. This must be done in thoughtful way so that the initial core scientific capabilities of the ESS are maintained. As a final point, NSS should work to better understand shielding costs including the bunker.

3. The NSS must continue to clarify scope ownership and the interfaces between NSS and other organizations within the ESS and between NSS and its external partners. This includes formal agreements, standards documents, etc.

4. The NSS must maintain robust communications between NSS and other organizations within the ESS and between NSS and its external partners.

5. The NSS must develop a detailed plan for multiple simultaneous installations and maintenance activities in the bunker and have it reviewed by an external committee.

6. The NSS should continue to refine its operational plan to efficiently and effectively deliver science at the beginning of user operations. A crucial element will be to ensure that sufficient staff, with the right skills, is identified in advance of this date.

7. The NSS operational plan should include funds to fully exploit the initial suite of instruments, including completion of the scope, procurement of an expanded set of sample environments, and to finish the promised complement of instruments. It should also provide resources for advancing the state-of-the-art in neutron instrumentation including instrument upgrades, neutron devices, and sample environments.

8. The development of the neutron test station must not divert resources from NSS or its attention from its primary activities as the relationship of the test station to delivering world-class neutron instrumentation at the beginning of ESS user operations is unclear.

5. SUBCOMMITTEE 5: CONVENTIONAL FACILITIES

5.1. Progress since last review

- Conventional facilities have made significant and visible progress on the construction site.

- Civil works for the Accelerator Tunnel are well advanced with some areas completed ahead of schedule.It is expected that the remaining works will be completed in-time for the Accelerator division to start installation of the LINAC and associated plant

- Civil works for the Cryoplant, Central Utilities building and Klystron Galleries are also well advanced.

- Piling under the Target Area is complete and well advanced in the Hot Cell Area as well as Bunker and experimental areas.

- Processes for design development were much improved since the last review with clear boundary between the Baseline Design team and the Detailed Design Team.

- Management of schedule, cost and risk were robust within CF and the CF team were able to demonstrate and communicate the status of the project in these areas.

- 2015 Review Action #1 requirements management has improved slightly but there is still concern that stakeholder requirements are being modified late in the design process.

- 2015 Review Action #2 Responsiveness of other Divisions appears to have improved but there is room for improvement in order to avoid further significant slippage in the CF schedule.

- 2015 Review Action #3 Issue related to design reviews have been addressed and stakeholder review now occurs at an earlier stage in the process (Preliminary Design Review).

- 2015 Review Action #4 concering missing items. It is noted that CF has a list of so called Orphan Items and these are now held at ESS senior management level.

- 2015 Review Action #5 Role of CF after handover has been defined. CF have been requested to take on Facility Management operations after buildings are handed over by C101 contractor. CF needs to put in place all necessary processes etc in order that they will be prepared for this new scope.

- 2015 Review Action #6. Improvements are noted in the risk register and risks area now included (partially at least) in P6. This a positive development.

- 2015 Review Action #7 The cost to completion was presented in a complete, clear and understandable way. In future, possible savings should also be presented.

5.2. Findings

- SC 5 considers that the CF Division is as well organised, well staffed and motivated Division.

- Their staff, consultants and contractors are experienced in their field and more than capable of delivering the buildings and building systems necessary for the ESS Project

- The worksite is well managed and although there have been a number of minor accidents, it is well organised with a high focus on safety. Recommendation: for future reporting, CF include comparisons with national statistics.

- Th C101 contractor SKANSKA, is a key partner to the project and the Cost + contract arrangment is well suited to the needs of the project (provides flexibility). Actual costs to date appear to be “beating“ the Target Cost. Recommendation: CF are more transparent on the relationship between Target Cost and EAC.

- There continue to be issues with the timely definition of requirements. This has in-part been the cause of the 7 month slippage to the milestone *Machine Ready for First Beam.*

- The CCB is an integral element of the overall project success. The output of the CCB needs to be timely, well documented and clearly communicated in order to avoid “corridor rumours“ relating to potential and ongoing changes.

- To some extent there is an “Us“and “Them“ culture between stakeholders including CF. More effort needs to be given to ensuring a single project focus across all disciplines.

- There is some slippage in the provision of offices and workshops mainly due to the need to develop a financing strategy as these will be paid from operations budget. This is now quite critical.

5.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

As all requirements are not yet known, this question cannot be answered positively. Given construction of the Target is underway, it is not acceptable that there are still uncertainties on Target Building requirements.

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

EAC have been prepared and they are clear. However, it is not clear that they are being used as a management tool.

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

No. Although CF and their contractor have schedules for their area of work, it appears that the integration of their schedules with other stakeholders is still an ongoing process. Again this is of concern given the status of the CF works and the proposed parallel working planned for the Target Building.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

Although CF has no in-kind procurements, in-kind procurements could have an impact on the CF schedule in particular if their installation is a pre-requisite to building works.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

Not at the moment but it is noted that CF have been requested to be prepared to take on Facility Management scope and work is ongoing in this respect (but budget aspects need to be addressed).

1.6 Are project risks identified, updated, and risk responses relevant and complete?

A risk register for CF was presented and management of the risks appeared to be satisfactory.

1.7 Does the organization match the needs of the construction project?

For CF yes, they are well organized and staffed appropriately. For ESS generally there still seems to be missing a body empowered to effectively undertake integration activities and it is considered there is still a large element of "stove-piping". As ESS moves into the installation phase, a re-organization is likely to be necessary to undertake installation activities in an efficient and global manner with consistency across the whole organization.

5.4. Critical issues

1. Unrecoverable schedule slippage: The current delay (at least 7 months) is not fully recoverable. A review of the schedule taking into account unrecoverable slippage, scope changes, cost constraints needs to be undertaken at the appropriate time.

2. Budget Constraints and Contingencies: the preparation of a formal list of possible descoping measures should be undertaken in order to have well planned and vetted options.

3. Clarity of Change Implementation: CCB decisions need to be more closely and formally linked to budget availability.

4. Readiness for Installation : The Organization needs to be better adapted to the future installation works. A single team for the management of all installation activities is recommended.

5. Requirements/Scope Definition: The Agreements between CF and other stakeholders must be signed off as soon as possible and not later than July 2016 and this should continue to be driven forward by senior management.

6. Project Culture: All stakeholders need to maintain focus on the single common goal to avoid the negative effects of "stovepiping".

5.5. In-kind status

- CF has no in-kind procurement

- However it must be noted that CF can be affected by in-kind status as late delivery of IK components could affect progress on Conventional Facilities.

5.6. Actions

1. Agreements between CF and other stakeholders to be signed ASAP (by July 2016).

2. Improved technical integration across the project to be implemented.

3. Change Control Board to include budgetary considerations and improve communication.

4. Formalized list of de-scope items to be prepared for rapid implementation if necessary.

5. An organizational structure suitable for installation activities needs to be developed.

6. Rules and regulations for installation activities need to be prepared and formalized at high level. Use of SKANSA existing rules is strongly recommended.

7. A timely decision on whether to implement acceleration measures for Target Area needs to be made.

6. SUBCOMMITTEE 6 COST & IN-KIND COORDINATION

6.1. Progress since last review

- EV 21% is impressive (up from 11% a year ago).

- Many IK (IKC) agreements are in place.

- 6 of 8 recommendations related to cost, schedule and IK have been implemented, the remaining 2, related to the liquidity gap and handling of multiple contracts with same vendor, are being addressed.

6.2. Findings

- Potential cost over-runs (92 M€) are still below the available contingency funds (160 M€), though their funding would result in an unacceptably low level of contingency remaining.

- Cumulative Planned (PV) and Earned (EV) Values and Schedule and Cost Variances in EVMS reporting are reset at the beginning of each fiscal year.

- The issue of VAT, income taxation of seconded IKC personnel@ESS, remains unresolved.

- IKCs are delayed because the preparation of TAs takes a lot of time and effort. IKC procedures do not appear to be followed in homogenous way across the different projects.

- Cost baseline changes authorized by CCB are not always followed by a draw on contingency funds. Nevertheless, in some cases, work was started immediately.

6.3. Committee charges

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

- Yes, however, EAC should not be the highest priority now. Instead, an integrated resource-driven project-wide schedule should be prepared, taking into account the reported ~ 7 month delay for the completion of the Target, which has a major impact on the overall project schedule and costs.

- EAC forecasting has been recently implemented, but not consistently for all projects. Currently, changes to the EAC in the monthly reports are derived by a software algorithm. A cost baseline and EAC should incorporate the integrated “orphan scope”

which – except for CF - appears to account for missing tasks, and does not represent an increase in scope. A new assessment of the EAC should follow the revision of the predicted cost and schedule.

- It appears that contingency funds are insufficient to cover identified risks and potential cost overruns due to project delays. Thus there is an urgent need to identify ways to create cost contingency, for instance by reductions in scope or by prioritization and staging of tasks. An analysis of all activities on or close to the critical path is needed to assess potential schedule risks.

- The current budget profile is inconsistent with the available funding. Given the annual profile of committed contributions from its member countries, ESS will run out of cash by the end of 2016, even if all approved contributions are received as planned.

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

- *No (see 1.2).*

- At present, the management system shows up to 1300 tasks on or near the critical path, apparently due to lack of project-wide updates of the data.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

- Yes, in the later phases of in-kind work. It is expected that for the earlier phases, the EC-funded Brightness project will offer useful tracking and assistance by its regional hub-partners.

- Scope of in-kind deliverables are incorporated and identified (agreed, planned, potential) in the planning and management tools. However, integration of these IK tasks into the schedule only as milestones is not optimal to assess progress, because possible design and prototyping phase variances are difficult to capture. It appears that some IK partners are prepared to descope if costs turn out to be higher than IK value (VAT problem or indexation).

- Hiring external experts to write TAs is a good idea for projects in a more advanced stage of planning. These experts should be involved in the IK negotiations and communicate directly with the central IKCM team.

- ICS should consider looking for expertise at other laboratories to prepare the IK contributions. PPS appears to be on the critical path and efforts should be concentrated on the TA. In 2016, there is less urgency for the preparation of the other ICS TAs.

- Although some 50% of expected TAs (235) are agreed or in preparation, the Committee remains concerned about the slow local follow-up and progress, i.e. setting schedules and milestones.

1.6 Are project risks identified, updated, and risk responses relevant and complete?

No. The risk register appears to contain items, which are entered inconsistently for the different projects. The software-calculated risk value is not well understood. It should include cost, staffing, programmatic, technical and schedule risks.

1.7 Does the organization match the needs of the construction project?

- Yes. As seen from our limited perspective, the staffing levels appear globally to be adequate for the presented plans.

- We observe significant changes in management and are concerned with the turnover rate. The Head of Integrated Control System is new since May last year (Henrik Carling). John Haines (who was previously Head of Target) is now Project Manager for Schedule. Eric Pitcher (previously Dep. Head of Target) is now Head of Target.

- The young ICS team appears to be generally competent, however, it lacks practical experience in many areas. Engagement of and consultations with experienced personnel at other laboratories could improve this situation, via IK collaborative contributions or by direct visits to gain hands on experience.

6.4. Critical issues

- Resource-loaded schedule revision across all divisions of the project to accommodate current delays.

- Realignment of milestones to create schedule float relative to the critical path (up to 1300 activities currently on the critical path) .

- Overall project liquidity gap.

- Completion of IKC TAs and start of work.

6.5. In-kind status

- 666 M€ worth of potential IK have been identified (36%), close to the target (41%).

- Integration of the SCRF cavities in cryomodules requires technical and managerial supervision.

- There are many small (low cost) contributions planned as in-kind procurements, which require significant attention to manage.

- The admin support, which is critical to successful execution of the in-kind process, seems to be effective.

6.6. Schedule related issues

- 50% of the expected IKC TAs (235) have been signed or are ready for signature.

- IK tasks with a total cost book value of 545 M€ are agreed or being planned. The targeted value of 675 M€ may be achievable, though 105 M€ remain quite uncertain and the attempt to find in-kind partners is balanced against potential delays if lengthy negotiations should be necessary.

- In 2016, the planned value of performed in-kind work is ca. 75 M€.

6.7. Actions

1. Under the leadership of ESS management, a thorough analysis should be performed to establish a project-wide resource loaded schedule, with the necessary interfaces and links between major tasks identified. The updated baseline plan needs to include schedule float relative to the critical path for most items, and should reflect the phasing of work, realistic staffing, and a realistic funding profile.

2. ESS management is advised to ask for approval by the Council at its June meeting to address the urgent problem of the liquidity gap in the coming years through means of creating adequate cash funds.

3. Related to the monitoring of IKC performance, a stronger presence of ESS staff at IK partner's home institution is advised, in particular in the early phases of the agreed execution of tasks.

4. The central IKCM team should work closely with the responsible work package managers, either directly or via a designated person(s) in the projects.

5. For planning purposes, specifically cash flow management, the value of in-kind contributions should be fixed to the current value of IK contributions agreed & planned (545 M€). Should this limit be exceeded in the future, the cash indexation could then be adjusted accordingly.

6. The cumulative SV and CV should be reported on a cumulative basis for the duration of the project, taking into account adjustments to the baseline.

7. The signing of the TAs should be expedited and largely completed by the end of this year. One should clearly and immediately identify, in which areas an end of year completion is not possible. For ICS, the project-requirements need to be established prior to the formulation of TAs.

8. Following revisions of the baseline cost and schedule, (see above), the risk registry should be updated, in accordance with common risk management guidelines.

9. Changes to the cost baseline authorized by the CCB must be followed by adjustments to the contingency funds, either spending or savings.

10. Collaboration between the Central IKCM team and the work package leaders in the preparation of Technical Annexes and the following oversight should be improved either by direct communication or via persons specifically assigned to these in-kind tasks.

7. SUBCOMMITTEE 7: SCHEDULE AND INITIAL OPERATIONS

7.1. Progress since last review

Impressive progress has been made on all fronts since the last review. ESS, at all levels, should be congratulated for their achievements! The sub-committee noted that:

a) Major Milestones have been achieved in :

- Civil Engineering
- Several successful prototype tests

b) The schedule and installation plan have been reviewed.

c) Milestone change control procedures are being routinely used.

d) Consideration of the transition to initial operations has begun.

7.2. Findings

a) Schedule -

- The integrated schedule is is becoming more robust, However it is not fully integrated yet and further concerted work is required to verify the input data, including the actual status of running tasks, task inter-dependencies and the effect of realistic resource-loading. This needs to be finished with some urgency.
- The schedule to date is managing a 12 months delay in conventional facilities. This is under review with significant mitigation being generated by increased work-rate and proposals for early access to allow parallel work. These measures will require intensive coordination and success will depend crucially on maintaining a close relationship with the conventional facilities contractor. The project will need to continue to work on methods to minimise the effect of the delay on first neutrons.
- The Change Control Board concept needs to be better formalized with appropriate scope and function and streamlined so that authorized scope changes include budget allocation.
- Significant unassigned “In-Kind” scope and orphaned scope is a risk to both cost and schedule, as there does not appear to be a coherent policy on funding or scheduling.

b) Risks-

- Risks identified and highlighted in the project are now very task orientated and focussed too much on “in-kind” issues. In constrast, personnel recruitment and retention and risks within the ESS internal project appear to have been neglected.

c) Operations –

- It is important to recruit the ESS operations manager very soon so that he/she can participate in, and eventually lead, work on defining the operational structures and processes.

- It remains urgent to complete definition and documentation of the safety management system and to transmit this, in the context of a safety culture, to the project participants, internal and external.

- The operations budget and staffing level plans for the ESS transition from construction through initial operation and finally into routine operation are still in their infancy and reflect the lack of operational experience in the project.

- The installation programme for the instruments, described as challenging, actually appears unrealistic with too many instruments being built at the same time. The ESS teams providing support do not appear to be resourced to acheive this. Resource-planning for instrument build and commissioning will need original thinking to solve problems across instruments rather than leaving them isolated. (eg organisation of multi-disciplinary “SWAT” teams).

- Initial operations costings should be revised to separate out spares, true operations costs and continued capital investment.

- The ICS team should assess and communicate the impact they may have on the schedule and establish requirements for Day1 of operation.

7.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

Orphan items are well known in the project but are not on the financial or project plan. These are considered to be requirements rather than nice to have items. The project should bring these to council

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates?

Great progress on the schedule has been made with well defined levels of milestones for the differing management needs. However, the use of milestones, which are ambiguous or weak, needs to be reduced to minimise confusion.

Not all projects are fully integrated into the schedule yet and this should now be completed.

The work to mitigate the target delay is positive but the sub-committee is concerned that quality may be compromised if poorly supervised work takes place to speed up construction.

The delay to access into the target building needs to be understood to make sure that further problems are spotted quickly and mitigated.

The use of float in the scheduling system is not consistent. Insistence on float between "ready for installation" milestones and critical path in a systematic way would substantially improve the resilience and clarity of the planning.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

The in-kind part of the project is just starting to take off. The project should be congratulated on the tremendous work that has gone on to secure the in kind so far captured. The sub-committee however noted that there is a large "bow-wave" of technical annexes to complete and is concerned that the teams are not well enough trained and resourced to deliver this. Some ESS staff should be trained in negotiations to improve the quality and efficacy of these documents.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

The project has only just started looking at this transition and has not yet developed a robust set of data. The project lacks operationally experienced staff to aid the process so this is very much work in progress. Hiring the overall ESS operations manager and defining the organisational structures for the operations phase should be a priority.

Operational budgets are not yet understood and the complexity of construction completion and the build-up of spares need to be separated to help clarify the numbers.

Most of data shown was a sub-set of 2013 and could not yet be described as bottom-up.

1.6 Are project risks identified, updated, and risk responses relevant and complete?

In some areas (e.g. Conventional Facilities) risks are understood better. There now seems too much focus on "in kind" risks and not enough on self-generated internal risks. In general, people-related risks (contractor relationship, staff competency profile in various teams, recruitment and retention) seem to be downplayed.

1.7 Does the organization match the needs of the construction project?

Yes, although in general the organisation chart still shows a substantial number of orphaned, disconnected technical service, administrative and even safety groups

1.8 Are the plans for host laboratory support functions (HR, IT, Legal, Finance, etc.) adequate to support the construction project?

It is surprising that on the organigramme, it is difficult to locate a Finance Director.

1.9 Are the plans for managing the regulatory permitting adequate for this stage of the project?

There is an impression of uncertainty about what is actually needed to get regulatory approval (e.g. major structural changes needed to make a sufficiently robust design or is the requirement for justification that the existing design will fail gracefully under a given stress scenario).

1.10 Are the Safety, Health and Environment and Quality Assurance functions being properly addressed at the project's current stage of development?

The Creation of an Environment, Safety and Health Division is to be applauded; however, as yet, there is little evidence of their wider influence within the project. The appearance is still one of factorised and independent safety approaches, risking differing standards and gaps in overview.

7.4. Critical issues

- A re-baselining will likely be needed to account for the target hall delay. This is probably a one-time opportunity, so should be used to produce as accurate a progress snap-shot and subsequent planning as possible, using the opportunity to introduce consistent float throughout the project.

- Soft influences such as the unresolved VAT situation can cause havoc with the costs and feed through into schedule.

- The operational budget, the required profile and the initial operations planning appear, as yet to be far from meaningful. Consideration of these is still superficial and requires more input from people with experience of operations .

7.5. Actions

1. Complete integrated schedule. Commit to a project tracking tool and implement it fully.

2. Produce a thorough post-mortem of how the delay in the target hall a) occurred b) was exposed. Ensure appropriate lessons are learned.

3. Start design work on the bunker immediately.

4. Appoint an operations manager (urgently).

5. Deliver training on negotiation to “In-Kind” team.

6. Deliver training on cost evaluation and repeat bottom-up exercise.

7. Provide particular support to the ICS team following recent major changes in management.

8. Use the first “in-kind” projects to evaluate milestone and monitoring methodology and make sure the findings of the evaluation are well distributed.

9. To aid resource smoothing during installation, prioritize instrument build and hot commissioning in manageable batches (e.g. 3).

8. SUBCOMMITTEE 8: MANAGEMENT AND PROJECT SUPPORT

8.1. Progress since last review

- In terms of project performance, ESS has made excellent progress over the past year.
    - Transitioned from ESS AB (LLC owned by Sweden and Denmark) into ERIC on October 1, 2015. All ESS assets, obligations and personnel transferred to ERIC.
    - The ESS Organization is now approaching 400 persons from 50 countries.
    - New Directors for Science and PS&A and the Radiation Protection Officer were recruited and on-board.
    - In-kind partners are identified for 545M€ with plans to achieve 685M€.
    - As of Feb 2016, ESS is approximately 21% complete (385M€ work accomplished), and is projecting 35% by end of 2016.
    - Approximately 14M€ of work has been performed by its in-kind partners.
    - Cash contingency on remaining work is ~12%.
- Further, ESS is commended for its effort to emphasize schedule performance as a key ingredient in successful project delivery. As the in-kind partners begin to ramp-up their efforts, shared ownership of the ESS schedule will remain critically important. Keep it going! Otherwise … ESS standing army costs are ~80M€/ yr!
- The Directors:
    - Implemented an overall technical coordination scheme which includes 3 Technical Coordinators to help ensure that ESS is a single coherent and integrated project.
    - Established a Technical Coordination Meeting to facilitate integrated solutions to cross-directorate issues.

    - Conducted a project-wide Alignment Workshop to clarify functional roles, responsibilities, authorities and approvals (R2A2). This is an excellent step in improving the communications and efficiency of ESS functions. The committee suggests having follow-on workshops after as a feedback loop.

- ESS has a reasonably functioning change control process and CCB with responsible owners to facilitate changes to the baseline

- Quality Assurance, Acceptance Testing is being implemented. Engaging the in-kind partner QA functions is the next step.

- Procurement planning is performing very well.

    - ERIC protocols, Agresso and ERP systems are in place.

    - Over 20 “large” procurements under contract per P6.

    - Developing several tools (catalog, e-procurement, etc.) to accommodate smaller procurements.

    - Staffing up to meet increasing demand.

    - However, ESS procurement should ensure adequate planning and awareness for IKC which have a high probability of being handled by ESS, particularly those IKC on the critical path.

- Separate risk registers manage ESS project risks. Currently >500 active risks are being tracked.

- The PSS was reviewed by ES&H and ESHAC in order to confirm the safety requirement.

8.2. Findings

- ESS has finalized its technical, cost and schedule objectives:

    – 5MW accelerator capability, 22 “public” instruments, 16 financed by construction project.

    – 1843M€2013 with an annual ops target of 140M€2013.

    – 1st Beam on Target December 2019, Installation complete by December 2022, 16 instruments delivered December 2025.

- The ESS delivery strategy includes the following features:

    – Conventional Facilities (CF) risk, within limits, owned by hosts.

    – In-kind (IK) deliverables defined (risk owned by IK partner).

  - "Ring-fence" budget ($350M€) defined for NSS Instruments.
  - 10% cash contingency held by ESS DG.
  - Scope contingency identified in accelerator energy.

- Concerning Technical Coordination, a structure is implemented, which is an improvement. However, the plan utilizes 3 project coordinators in a facilitation role, without authority, resources or budget. The organization retains a strong silo functionality that often creates integration gaps and redundant activites (e.g., radiation shielding).

- A project management handbook is under development. This document should be completed (and actively socialized) as soon as possible.

- Project financing in total, from the Hosts and In-Kind Partners has been identified, however annual cash resources will soon be insufficient to meet the peak construction spending rate and is a critical issue. Several solutions have been proposed, however none is in place today. This is a critical issue which needs immediate resolution.

- ESS is to be commended for its efforts in securing partners to support its In-Kind Contributions. However, implementing the VAT tax exemption (provided in the ERIC agreement) for each in-kind country is a major issue which will soon impact the project's overall schedule. ESS management should work agressively with the ERIC Council and the ESS Administration and Finance Committee (AFC) to resolve as soon as possible.

- Quality Assurance and Risk Management functions need to continue progress in implementation uniformly across the organization. There is some concern these policies (approved at Level 1) are perhaps too theoretical and not being implemented effectively down the organization. Move toward more practical and simple functionality and then implemente project-wide.

- The ESS application for regulatory license for installation is due May 1, 2016. ESS is doing a good job maintaining schedule on this critical milestone. There are concerns however, that subsequent licensing approval milestones may end up on the project critical path. Continued ongoing engagement with the regulating authority is needed and effort should be placed on decoupling the Installation License from a Commissioning/Operating License.

- Focused discussions on Accelerator Readiness Review (ARR) process which will be used to support readiness to commission and is used widely at other accelerator facilities.

- Shielding design remains distributed (at least 3 groups), which may be an effect of the strong silo organization. The project would benefit from one organization.

- A radiation waste contractor and disposal path have been identfied.
- The ESH organization lacks accelerator safety expertise and in as much does not have the experience and knowledge to oversee design aspects.
- A project-level baseline hazards analysis (HA) was not available. The HA is a global document providing a framework for developing requirements on a risk based approach to address ESH issues uniformly across the project. This should be developed soon.
- ESS ES&H has good communication with other safety groups in Acc, Target, ICS, SE, etc. However, the knowledge and drive of the ES&H Organization seems weak. For operating and maintaining ESS safely, the effective design of radiation monitoring and the establishment of rules for radiation protection are essential. The contribution of ES&H to safety at all facilities is quite important from the designing stage.

8.3. Committee charges

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

Yes, for the most part. ESS performance baseline was established in November 2013 and has been measuring earned-value against the baseline since that time. The Work Breakdown Structure is stable and configuration controls are in place to management the baseline and technical requirements. Some “orphan” scope has been identified which needs resolution.

1.2 Are Estimates-At-Completion prepared and updated as a management tool?

Yes, the schedule is complete with linked resource-loaded activities and key milestones for interfaces and in-kind deliverables. The schedule is characterized as “aggressive” and recent indications are that schedule slip may occur in the near term.

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

Yes, in-kind contributions and procurements are well defined. The procurement process is well along. However, the IKC definition effort is just underway and more work is needed in 2016 to stay to schedule The question of the VAT is not yet resolved which may significantly impact the cost and schedule of the IKCs.

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definition of the project completion milestones describing a minimum level of performance?

Yes, an initial operations budget is in place. The ESS team should continue to emphasize the critical need of 2019 operating funding. From an ESH perspective, more work is needed with

respect to “accelerator readiness”, but the project is engaged in the readiness process and the regulator.

1.6 Are the project risks identified, updated and risk responses relevant and complete?

Not entirely. A lot of work has been done, however there are multiple risk registers and how risks are collectively assessed and managed need more uniformity. From an ES&H perspective, a project-level baseline hazards assessment is needed to determine if all ESH risks have been identified.

1.7 Does the organization match the needs of the construction project?

Yes, for the most part. With a DG search underway some future changes are probable, which will take time to assimilate. The organization shows signs of strong silos and perhaps some overlap between functions, indicating the need for stronger central coordination. The new ES&H Director should have a strong background in accelerators and user facilities.

1.8 Are the plans for host laboratory support functions (HR, IT, Legal, Finance, etc.) adequate to support the construction project?

Yes, all ESS host lab functions appear to be up and running, although the budget at 7% of the base cost is low when compared to other large science projects. The demand on the host functions will grow as ESS moves into the installation, commissioning and eventually operations phases.

1.9 Are the plans for managing the regulatory permitting adequate for this stage of the construction project?

Yes, but be very cautious (and proactive) of deadline commitments by permitting agency.

1.10 Are the Environment, Safety and Health and Quality Assurance functions being properly address at the project’s current stage of development?

Not entirely. ES&H and Quality Assurance policies are in reasonable shape, but there is more to do on implementing uniform processes across ESS and its in-kind partners.

8.4. Critical Issues

- There is a strong likelihood that ESS will run out of cash in the later half of 2016. It is essential to have a viable plan now for a final decision at the June Council meeting.
- Implementing the VAT exemption at the ESS in-kind countries is beginning to impact the project’s ability to award large procurements, many of which are on the project critical path. It is urgent that solution(s) are identified immediately to avoid affecting the overall project schedule.
- The ESS technical coordination scheme is helping facilitate integration gaps and the appointment of a Schedule Project Manager is helping to integrate the schedule,

however there is still no single person (except the DG) with overall responsibility, accountability and appropriately wide authority for ensuring coherent delivery across the full scope of the project. This issue should be revisited.

- The lack of a long-term policy on in-kind and seconded staff working in Lund, Sweden will begin to have an effect on the project in 2016.

- ESS does not have ESH leadership with accelerator/user facility experience that can drive the present ESH program accross the Project. It is critical that this hire be made soon.

- The Project will rely heavily on the present construction GC to manage all work activities before buildings are transitioned to ESS. A global requirements document that defines how all Work Planning and Control (authorizations, tasks, safety reviews, releases etc.) as well as well defined R2A2s, integrated task planning, and clear communication is needed.

- Beyond the permitting process, ESH needs to define the level of engagement with facility design, installation and operations.

    - Roles, Responsibilities, Accountability and Authority – what is ESH responsible for? (SAD, ASE, Configuration Management, design approvals etc. Although ESH has assurance responsibilities, ESH needs to provide assistance in many areas too).

    - What is the ESH staffing plan for the out-years?

8.5. In-kind status

- In-kind work ramps up steeply in 2016-2018. Overall, the number of IKC agreements needed are ~40-50, with 6 currently in place. For TAs, ~250 are needed with 20 in place. The IKC management team is aware that much more work is needed, particularly in 2016, and has assembled a dashboard to track process.

- A potential obstacle to fully implementing In-Kind Contributions (IKC) is the VAT exemption. Overall impact of the VAT exemption is estimated to be ~40-50M€. Many of the IKC are on the overall critical path and need to be procured on their planned schedule to avoid significant schedule delay.

- There are substantial tax liability barriers to long-term employment for ESS staff and in-kind seconded employees. These barriers are having an effect in 2016 and will only grow as more in-kind work ramps up.

8.6. Actions

1. Overall Technical Coordination and Project Management needs further strengthening (repeat recommendation).

2. ESS management should work with the Hosts to develop a long-term taxation policy to address ESS in-kind staffing (seconded) issues.

3. After incorporating feedback from the Alignment Workshops, finalize the Project Managment Handbook and communicate broadly across ESS.

4. Track process on IKC Agreement dashboard on a monthly basis and report progess at the EMT meeting.

5. A DG Transition Plan should be developed identifying risks and mitigations over the next year.

6. The project should consider a single project-wide risk register and focus its attention on the risks having the most impact on the project (typically <20).

7. The project should hire an ESH Associate Director with experience in accelerator/user facilities and construction safety as soon as possible.

8. The project should develop a project-level baseline hazards assessment as soon as possible to ensure all ESH risks have been identified.

9. The project should develop a WPC interface document for installation/commissioning activities for areas that have not transitioned over to ESS.

Appendix 1

Version: 2.1

Terms of Reference

European Spallation Source

3rd Annual Project Review

19-22 April 2016

The 2nd Annual Project Review was completed in April 2015 and a report issued in May 2015. A self-assessment measuring progress addressing the actions and recommendations from this review was completed in November 2015 along with a report.

1. Committee Charge for the 3rd Annual Review

1.1 Is the scope of work adequately defined and do plans include all the activities necessary to deliver the construction project, including a reasonable breakdown of requirements, interfaces and provision for design reviews and verification activities?

1.2 Are Estimates-at-Completion prepared and updated as a management tool?

1.3 Is the schedule adequately integrated, tracked and managed, and consistent with the major construction project external delivery dates[1]?

1.4 Are in-kind deliverables and procurement contracts, including long lead items and procurements requiring R&D, properly identified and sufficiently planned and managed?

1.5 Is the transition from the Construction Phase into the Initial Operations Phase clearly and appropriately defined and is there clear definitions of the project completion milestones describing a minimum level of performance?

1.6 Are project risks identified, updated, and risk responses relevant and complete?

1.7 Does the organization match the needs of the construction project?

1.8 Are the plans for host laboratory support functions (HR, IT, Legal, Finance, etc.) adequate to support the construction project?

1.9 Are the plans for managing the regulatory permitting adequate for this stage of the project?

1.10 Are the Safety, Health and Environment and Quality Assurance functions being properly addressed at the project's current stage of development?

---

[1] *Target ready for beam December 2019, Machine fully installed December 2022, User Program in 2023 and 16 instruments delivered December 2025.*

Number	Name	Focus areas of the charge
Subcommittee 1	Accelerator	1.1 - 1.7
Subcommittee 2	Target	1.1 - 1.7
Subcommittee 3	Integrated Control System	1.1 - 1.7
Subcommittee 4	Neutron Scattering Systems	1.1 - 1.7
Subcommittee 5	Conventional Facilities	1.1 - 1.7
Subcommittee 6	Cost and In-kind coordination	1.2, 1.4, 1.6 & 1.7
Subcommittee 7	Schedule and Initial Operations	1.3, 1.4, 1,5, 1.6, 1.7 & 1.8
Subcommittee 8	Management and Project Support (incl. ES&H and QA)	1.1, 1.2, 1.4 – 1.10

Appendix 2

ESS 3rd Annual Project Review

Version: 12

19-22 April 2016
Lund, Sweden

Tuesday, April 19 2016 – Auditorium, Medicon Village

8:00	Bus from Hotel Planetstaden to Medicon Village
8:30	Committee Executive Session..... Review Committee Chair
9:15	Welcome and ESS Overview and Status (25+15) ..... J. Yeck
9:55	Science Objectives (15+10) ..... A.Schreyer
10:20	*Break*
10:40	Facility Performance Objectives (15+10).....R. Garoby
11:05	Schedule and Initial Operations (20+10).....J. Haines
11:35	Accelerator System (20+10) ..... M. Lindroos
12:05	Target System (20+10) ..... E.Pitcher
12:35	*Lunch*
13:30	Integrated Control System (15+10) ..... H.Carling
13:55	Neutron Scattering System (20+10) .....S. Kennedy
14:25	Conventional Facilities (15+10) .....K. Hedin
14:50	Cost and In-Kind Coordination (15+10)..... A.Weeks
15:15	Management & Project Support (incl.ES&H, QA) (15+10) .....A.Nestenborg
15.40	*Break*
16:00	Conclusion of Plenary Presentations .....J. Yeck
16:30	Committee Executive Session..... Review Committee Chair
18:30	Bus from the auditorium at Medicon Village to the Restaurant
19:00	Reception and Dinner

Wednesday, April 20, 2016 - Conference rooms according to detailed schedule, ESS

8:10	Bus from Hotel Planetstaden to Construction site for tour on bus
9:30	Parallel Subcommittee Presentations/Discussions
12:15	Lunch
13:15	Parallel Subcommittee Presentations/Discussions
16:00	Review Committee Executive Session .....Christinehof, Conf. Centre
18:00	Transport from ESS to Hotel Planetstaden for those who do not attend the Poster Session – Please register at the reception for transport
18:00	Poster Session ..... Ljusgården in 205
20:00	Bus from ESS to Hotel Planetstaden

Thursday, April 21, 2016 - Conference rooms according to detailed schedule, ESS

8:10	Bus from Hotel Planetstaden to ESS
8:30	Parallel Subcommittee Presentation/Discussions
12:15	*Lunch*
13:15	Parallel Subcommittee Presentations/Discussions
15:00	Subcommittee Working Sessions
16:00	Review Committee Executive Session .....Christinehof, Conf. Centre
18:00	Bus from ESS to Hotel Planetstaden

Friday, April 22, 2016 – Auditorium, Medicon Village

8:10	Bus from Hotel Planetstaden to Medicon Village
8:30	Review Committee Executive Session ....Auditorium, Medicon Village
10:30	Dry Run of Closeout Briefing
11:30	Closeout .....Auditorium, Medicon Village
12:30	Adjourn and Lunch
12:30-15:00	Transport to Copenhagen Airport/Lund Central Station/Hotel Planetstaden

Appendix 3

Version: 3.13

3rd Annual Project Review
European Spallation Source ERIC (ESS)
19 - 22 April 2016

Committee Chair, Marzio Nessi, CERN
Committee Coordinator, Johan Brisfors, ESS

Subcommittee 1 Accelerator System (ESS PoC: Mats Lindroos)	Subcommittee 2 Target System (ESS PoC: Eric Pitcher)	Subcommittee 3 Integrated Control System (ESS PoC: Henrik Carling)
* **Sergei Nagaitev, Fermilab**	* **Georg Bollen, MSU**	* **Mark Heron, Diamond**
* Jean-Pierre Delahaye, CERN (ret.)	* Matt Fletcher,ISIS	* Anders Wallander, ITER
* Alan Letchford, ISIS	* Kurt Clausen, PSI	* Karen White, SNS
* Angeles Faus-Golfe, IFIC		

Subcommittee 4 Neutron Scattering Systems (ESS PoC: Shane Kennedy)	Subcommittee 5 Conventional Facilities (ESS PoC: Kent Hedin)	Subcommittee 6 Cost and In-Kind Coordination (ESS PoC: Allen Weeks)
* **Dan Neumann, NIST**	* **Tim Watson, ITER**	* **Markus Nordberg, CERN**
* Thomas Proffen, SNS	* Tim Broome, ISIS (ret.)	* Vera Luth, SLAC
* Ken Herwig, SNS	* Chris Mossey, FNAL	* Cathy Lavelle, BNL
* Mark Johnson, ILL	* Sven Landelius, CFAC	* David Urner, FAIR
* Toshi Kanaya, KEK		

Subcommittee 7 Schedule and Initial Operations (ESS PoC: John Haines)	Subcommittee 8 Management and Project Support (incl. ES&H and QA) (ESS PoC: Therése Welander)
* **Austin Ball, CERN**	* **Mark Reichanadter, SLAC**
* Zoe Bowden, ISIS	* Ian Evans, SLAC
	* Luis Sanchez-Ortiz, ESRF
	* Tetsuro ISHII, J-PARC

Observers

* Lars Börjesson, Chair ESS Council
* Caterina Petrillo, Vice Chair ESS Council
* Bernard Dormy, Chair ESS AFC
* Neil Pratt, Vice Chair ESS AFC
* Kjell Möller, Swedish Research Council
* Leif Eriksson, Swedish Research Council
* Johan Holmberg, Swedish Research Council
* Kjell Arefjäll, Swedish Research Council
* Camilla Jakobsson, Swedish Research Council
* Sofie Björlin, Swedish Research Council
* Mårten Jansson, Swedish Research Council
* Justin Greenhalg, STFC
* Amina Taleb, France Representative Council
* Jose Luis Martinez, Spain Representative Council
* David Edvardsson, Swedish Ministry of Education and Research
* Morten Scharff, Danish Ministry of Science, Innovation and Higher Education
* Fredrik Melander, Senior advisor at the Danish Ministry of Science, Innovation and Higher Education
* Bo Smith, Denmark Representative Council
* Lars Christensen, Danish Ministry of Science, Innovation and Higher Education

(**Bold** = Sub-committee chair)
(* = confirmed)

Review Committee members