Fermilab

Final Report

Director's Progress Review of the Short Baseline Neutrino Program

June 26-28, 2018

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1.0 Executive Summary

A Director's Progress Review of the Short-baseline Neutrino Program (SBN) was held June 26 - 28, 2018. The primary focus of the review was on the technically driven schedule to reach a set of key milestones for each of the detectors, far (ICARUS T-600) and near (SBND), that are being constructed and installed for operation in the Booster Neutrino Beamline.

The key milestones for the SBN Program are :

- I-1 ICARUS vessels are ready to fill with LAr
- I-2 ICARUS detector is ready for commissioning (LAr pure and all electronics and readout installed)
- I-3 ICARUS detector ready for physics data (CRT and shielding installed)
- S-1 SBND TPC is ready to move to ND building
- S-2 SBND cryostat is ready to fill with LAr
- S-3 SBND detector is ready for commissioning (LAr pure and all electronics and readout installed)
- S-4 SBND detector ready for physics data (CRT and shielding installed)

To review the schedules for reaching these milestones the review committee organized into the following breakout session :

- ICARUS Electronics (TPC and PMT)
- ICARUS Installation
- SBND Electronics
- SBND Detector and Cryostat
- SBND Installation
- Cryogenics (Far and Near Detectors)
- DAQ and Common Online

The review committee was pleased with the completeness of the presentations for each of the sub-systems. Schedules for reaching each of the key milestones were presented. The proponents had a good handle on the tasks needed and were well prepared to discuss details. The contributions from our international partners were particularly appreciated. The main conclusion of the review was that while an overall integrated schedule for completion of each detector was not available, the information needed to create these schedules does exist.

The review did not address technical performance or costs. However, once the proponents prepare an updated, integrated schedule which reflects many elements that have been missing to date, this can then be used to update the "cost to complete".

The committee was instructed to consider that "technically driven" must include the time needed to get all safety clearances and to investigate whether the resources to prepare for safety reviews are available in a timely way such that the review process does not drive the schedule.

In general the committee felt that the teams had a good handle on what will be required to stay on top of the review process and is in the process of preparing the needed documentation.

The committee also reviewed outstanding risks, that if realized would impact the ability of the program to keep on schedule. The committee felt that the sub-system teams had a good handle on their risks and are working towards mitigating outstanding risks.

The committee notes that to date the schedule for the installation of the far detector cold vessels has encountered a number of serious delays, however, the near term schedule for getting the vessels installed will be a significant achievement and careful planning of all the tasks going forward will be needed to try and accelerate the achievements of key milestones I-1 and I-2.

Finally, it is extremely important that the agreements needed to begin the final design of the near detector cryostat be put into place as soon as possible, so that the schedule for the construction of the cryostat does not significantly delay achieving the milestones S-2 and S-3.

2.0 Introduction

A Director's Progress Review of the Short Baseline Neutrino (SBN) Program was held on June 26th – 28th, 2018 at Fermilab. The focus of this review was to assess the technically driven schedule for construction, installation, commissioning and the associated milestones. The review also addressed program management and ES&H as it pertains to the technically driven schedule.

3.0 Construction, Installation, and Commissioning

a. ICARUS Far Detector TPC and PMT Front-End

Subcommittee: Michelle Stancari, Gary Drake

Charge Questions:

Is the overall progress on ICARUS installation, cryogenics, construction and commissioning consistent with the planned milestones?

Yes. The team is making good progress in the production and checkout of the front-end subsystems. The major milestones are understood. The installation and commissioning tasks have been identified. Planning for execution is in progress.

Is the process for establishing milestones sound and tractable?

Yes, major milestones are understood, but the schedules lack intermediate milestones and details, and coordination with the overall program has not yet occurred at a sufficient level.

Are appropriate program driven technical reviews being planned, conducted and responded to?

None are currently planned for this program area. Production of subcomponents is underway.

Are interfaces being adequately addressed?

Yes, interfaces seem to be understood, although no interface documents were presented.

Findings

- The subcomponents for the TPC and PMT electronics are all in production. The proponents are on track for completion and delivery of all subcomponents. The delivery schedule to Fermilab is consistent with their installation plans.
- The dates stated by the proponents for installation of the TPC and PMT electronics into the detector do not match the Microsoft Project, nor the installation plan from the program.
- Details and intermediate milestones for the installation of the TPC and PMT subsystems have not been identified in the schedules presented.
- Both the TPC and PMT electronics groups have identified and quantified the need for manpower support from US institutions for installation and commissioning.

Comments

- The proponents are well along with the construction of the subcomponents. All major technical issues have been addressed.

- While the TPC and PMT electronics proponents did not have formal BOEs, upon drill-down they were able to articulate a good understanding of the effort needed for production and checkout at their home institutions. Much of this work is already in progress.
- While all of the major installation and commissioning tasks have been identified by the proponents, the schedules for both the TPC and PMT electronics seemed tight, planned for success, and optimistic.
- The proponents are requesting support from US institutions (labs and universities), to assist with the installation and commissioning. This has not been formalized as yet to the project, and was stated to be in progress. **The presented schedule cannot be achieved without this additional effort.**
- There did not seem to be adequate incorporation of tasks and activities associated with the TPC and PMT electronics in the schedules from the program or from the installation group. **Interdependencies and conflicts with other installation tasks have not been studied or identified.**
- Early testing of a small piece of the installed system - a "Vertical Slice Test" - was suggested before installation proceeds in earnest.
- The PMT flanges cannot be installed and cabled for each penetration until the TPC flange is installed and cabled for that penetration. A late delivery of the TPC components, or a decision not to proceed with the TPC flange installation until issues found in the Vertical Slice Test are resolved, could cause the entire schedule to slide. The committee supports this proposal and suggests that it proceed as soon as possible.
- A Vertical Slice Test of the PMT system cannot be performed until they are "dark," and the DAQ and HV racks are built, tested and have safety reviews. This also applies to any Vertical Slice Test of the integrated PMT-TPC system.
- No details of the class-3b laser installation were available. No time was scheduled for safety review of the laser system. This is not on the critical path, but the 2 weeks that the responsible persons from INFN Milano are planning to be at FNAL for installation of the laser and its light distribution system to the flanges will likely not be sufficient if the safety reviews must also be done in this time.

Recommendations

1. Review the TPC and PMT electronics installation and commissioning plans, and develop detailed plans including allocation for duty factor and contingency in the effort estimates. Incorporate these schedules into the master installation and commissioning schedule.
2. Work with the installation coordinator to identify support needed from Fermilab for services such as rigging, crane operation, cable pulling, etc. These should be incorporated into the overall planning for the ICARUS detector installation.
3. Proceed as soon as possible with requests for safety reviews, ORCs, etc. In particular, safety and operational issues associated with the laser should be addressed.

b. SBND Front-End

Subcommittee: Dave Christian, Pam Klabbers

Charge Questions:

Is the overall progress on SBND installation, cryogenics, construction and commissioning consistent with the planned milestones?

Yes.

Is the process for establishing milestones sound and tractable?

Yes.

Are appropriate program driven technical reviews being planned, conducted and responded to?

Yes.

Are interfaces being adequately addressed?

Yes.

Findings

- The BNL and Manchester groups have conducted a series of tests of Commercial Off-The-Shelf (COTS) ADCs to identify a COTS ADC suitable for use at liquid argon temperature in SBND.
- These tests have demonstrated that the Analog Devices AD7274 ADC will not suffer accelerated aging due to the hot carrier effect if operated at 2.5V.
- Based on these results, SBND has decided to use a Front-End MotherBoard (FEMB) design that uses AD7274 ADCs.
- A minor redesign of the FEMB and FPGA mezzanine card is planned. Tests to date have used the mezzanine card designed for use with the P1 ASIC ADCs used in protoDUNE. The P1 ADC has a differential output whereas the AD7274 has a single-ended output. The redesigned motherboard and mezzanine will be optimized for single-ended connections to the FPGA. The mounting holes in the motherboard will also be moved to facilitate mounting on SBND APAs.
- The second prototype version of all Nevis readout modules is fully functional and needs no further revision.

- A small-scale test of SBND cold electronics (FEMBs, cold cables, WIB, PTC, + Nevis readout) using near final prototype modules has been successfully completed at Nevis Lab. These modules are now at Fermilab and will be used in a vertical slice test in LArIAT.

- The Operational Readiness Review conducted at Fermilab for the LArIAT vertical slice test identified one undersized part (an inductor) on the PTC. The PTC installed for the vertical slice test has been modified and the modification has been included in the SBND PTC design.

- Because of work done in preparation for the LArIAT vertical slice test, development of the SBND TPC electronics is ahead of schedule. Three production readiness and safety reviews have been planned; one in October 2018 for cold electronics, one late in December 2018 for the cold cables and feedthrough board, and one in March 2019 for warm interface electronics. The group now expects that all three of these reviews can be combined and held at the end of October 2018.

- The group plans to cold test LArASIC front end ICs and use only known-good parts in the fabrication of FEMBs. This testing has begun and is being done at BNL organized by a Colorado State graduate student.

- QC for FEMBs will include testing cold as well as warm and multiple thermal cycles. WIBs will be tested using FEMBs as input; outputs will be received using a TLK2501 evaluation board (the TLK2501 is the receiver used on the Nevis Front End Module).

Comments

- The schedule documented in the "May 2018 Excel File of Schedule" (SBN-doc-246) shows that installation and testing of TPC readout electronics in DAB is on or very close to the critical path to the first key SBND milestone (S1: SBND is ready for transport from Dzero Assembly Building to the SBN ND hall). The plan to hold all three production readiness and safety reviews for the BNL-provided TPC electronics elements to October 2018 should improve the schedule for delivery of these components to Fermilab by approximately 8 weeks. This will greatly improve the odds that the S1 milestone will be met on time.

- Similarly, the production readiness and safety review for the Nevis-provided TPC readout will occur in August 2018 rather than in February 2019. Even taking into account the time delay anticipated for long-lead time components, this should add a four-month cushion to the overall schedule.

- The SBND group should ensure that all of the engineering analysis documents related to TPC electronics that will be required for the SBND ORC are completed satisfactorily at the time of the production readiness and safety reviews. This will ensure that no retrofits are required to the production modules.

- Sufficient BNL and Nevis resources are available for remaining design, production, and installation tasks.

Recommendations

None.

c. Common DAQ, Slow Controls, and Monitoring

Subcommittee: Jim Patrick, Ryan Rivera

Charge Questions:

Is the overall progress on installation, cryogenics, construction and commissioning consistent with the planned milestones?

Yes.

Is the process for establishing milestones sound and tractable?

Intermediate milestones need to be developed and tracked.

Are appropriate program driven technical reviews being planned, conducted and responded to?

SBND has a technical review planned for this year. ICARUS has no planned technical reviews.

Are interfaces being adequately addressed?

Yes, but a controlled interface document would be helpful to insure that interfaces are respected.

Findings

- The Common DAQ, Slow Controls, and Monitoring deliverables do not include procurement of the physical racks. The scope does include the procurement of (non-networking) cabling, SBND power supplies, computer servers, and their installation. For ICARUS, cabling from racks to the detector is outside the scope of Common DAQ. For SBND, cabling from racks to the detector is within their scope.

- Once the server hardware has been procured, work can proceed remotely. Iterating on GUIs to improve user-friendliness can proceed without interfering with the progress of commissioning activities.

- The common DAQ framework, event building, and data logging software is a deliverable for protoDUNE for fall 2018, which is a good driver for debugging and commissioning the features needed for SBN DAQ.

- ICARUS is relying on data emulators until hardware arrives to proceed with software development of BoardReader plugins for *artdaq*.

- For both SBND and ICARUS, the DAQ bandwidth is planned to handle untriggered, lossless compressed data rates with consideration for detector noise. Steady state running is expected to produce a factor of 5 to 10 less data.

- INFN scientific and technical labor resources have been planned in detail and are making significant contributions to the Common DAQ, Slow Controls, and Monitoring.

- The Common DAQ, Slow Controls, and Monitoring team manages their schedule through an exported Excel spreadsheet and email, not through the Microsoft Project tool.

- SBND DAQ is planning a Final Design technical review in 2018.

- CERN White Rabbit hardware forms the timing system for SBN. Most White Rabbit hardware is in-hand. The CERN White Rabbit development team is generally responsive to questions and their is an active user community.

Comments

- The Common DAQ, Slow Controls, and Monitoring team is strong and experienced with abilities that align well to the deliverables.

- There is adequate time to achieve the DAQ and Slow Controls deliverables, which are primarily software deliverables.

- The SBND vertical slice test at the Fermilab Test Beam Facility has proved valuable for demonstrating key DAQ and Slow Controls deliverables.

- Lab support for the maturation of White Rabbit firmware expertise at Fermilab, especially with regard to the Mock Turtle (Fine-Delay Mezzanine), is valuable to the timing and synchronization efforts of SBN and other future projects at Fermilab.

- The cable installation plan for the SBND power and data cables currently relies heavily on uncosted labor resources. It will be important to monitor installation progress and quality to avoid delays in receiving operational readiness clearance.

- It was identified that the ICARUS racks currently do not have planned a mechanism for recording temperature as a function of time for each rack (i.e. there is no Slow Controls box). It may be worth considering using the Slow Controls boxes planned for SBND.

- Considering potential labor resource conflicts with Mu2e commissioning could be important for avoiding schedule delays in the years 2019 and 2020. Specifically, labor resource examples with demands from both experiments may be PPD technicians, CCD networking, SCD offline, SCD *artdaq* core developers, and SCD node management.

- ICARUS DAQ has not performed an external technical review and has no planned external technical review. It may be valuable to conduct a technical review.

Recommendations

4. Identify appropriate and descriptive intermediate milestones with the goal of giving more progress visibility to program management. A good target would be one milestone per level three WBS at two to three month intervals. Intermediate milestones that have dependency links across subsystems should be considered.

5. Create an installation procedure document that details the responsibilities of uncosted labor and technical staff.

6. Create an interface document that details the external interfaces with other subsystems and obtain the sign-off from their team leads.

d. SBND Detector and Cryostat

Subcommittee: Bruce Baller, Don Mitchell

Charge Questions:

Is the overall progress on SBND installation, cryogenics, construction and commissioning consistent with the planned milestones?

Yes

Is the process for establishing milestones sound and tractable?

Yes

Are appropriate program driven technical reviews being planned, conducted and responded to?

Yes

Are interfaces being adequately addressed?

Yes

Findings

- A conceptual design of the cryostat exists. Design of the support steel structure by CERN, with INFN input, is complete.

- The final cryostat designed will be by GTT, a vendor with extensive experience building similar systems after a contract has been signed. However, the contract cannot be awarded until cost sharing is agreed upon. An MOU is being developed to declare institutional responsibilities and contributions. The start date is the only unknown. All design and fabrication milestones for the cryostat are well known. Once the start date is established, the installation schedule will be complete. There is a direct impact to the schedule which has made this issue a top priority for SBN. This is a well known issue that the SBN management team is working hard to resolve.

- Since most of the detector construction effort is now in the fabrication phase, the time estimates for completion of tasks are very straightforward to estimate. The schedule is up-to-date and incorporating all known delays.

- All engineering documentation is being collected and will be prepared in time for the ORC review.

- There is a formal Integrated Control Document being managed on Docdb for the full integration of every sub-system of the detector and cryostat.

- For the cryostat, design modifications to lower cost have been integrated into the conceptual design.

- Interfaces with the cosmic ray tagger, laser calibration system and photon detection systems are well-defined.

- A design for attaching cable trays to the APA frames was recently developed. This design does not require any welding or machining of the APA frames.

Comments

- There is good collaboration effort on the sub-system fabrication. This is being managed effectively.

- Wire winding in the UK and US is progressing well. There was a cumulative 3 month delay in the original schedule caused by the need to correct fabrication errors and parts delivery delays. All assembly processes have now been exercised and are well understood. The schedule is based on the known production rate and the percent complete.

- Resources are well defined.

- There are plans to perform a mechanical cold test of the UK APAs. A decision has been made to not test the US APAs. The rationale given for this decision is to minimize the risk of damage during transportation and handling.

- It is noteworthy that a significant recommendation at the November 2017 review, “The program office should evaluate the cost and schedule impact of late APA delivery” is obviated by the scheduled delivery of the first APAs in August.

- There is an opportunity to begin the engineering note process of a major portion of the cryostat since the steel structure design is complete. The steel structure supports all the hydraulic and pneumatic pressure loads.

- The definition of sub-systems that are (not) subject to import duties needs continued attention. Of particular importance is the method of “procurement” of the cryostat and APAs. The definition may not result in a significant cost or schedule impact for SBN but could set a precedent that could affect LBNF/DUNE adversely.

- Continue applying pressure on all shipping documentation. Long delays on importing materials from overseas can severely impact the schedule. Currently being addressed.

Recommendations

7. Initiate a FESHM 5031.7 membrane vessel engineering note for the cryostat warm structure prior to the initiation of the GTT membrane design study.

e. External and Proximity Cryogenics

Subcommittee: Jack Fowler, Mike White

Charge Questions:

1. Is the overall progress on installation, cryogenics, construction and commissioning consistent with the planned milestones?

   Yes; however, only the schedules into the future were reviewed. Progress to date based on past schedules was not reviewed in detail. The fraction completed on all high-level tasks has increased since the December 2017 review.

2. Is the process for establishing milestones sound and tractable?

   Yes. Only high-level schedules were reviewed, but it was clear that there were many sub-schedules built into the high level schedule. Statuses of specific tasks were reported in precise numbers, such as 29%, 53%, or 92% complete.

3. Are appropriate program driven technical reviews being planned, conducted and responded to?

   Yes, in particular all safety reviews are explicitly in the schedule. Over 60 engineering notes are expected to be produced by the time ORC is given. The status of each engineering note is tracked using an Excel spreadsheet. Some engineering notes have already been submitted to the cryogenic review panel.

4. Are interfaces being adequately addressed?

   Yes, but all scope is not yet fully defined for several sub-project areas.

Findings

- The Protego valve for side penetrations takes 40 weeks to deliver upon placement of order for NP03. Recent increase in SBND insulation thickness to 80 mm now matches ProtoDUNE, so minimal design work should be required.

- Equipment used by European collaborators and subcontractors requires 220V/50 Hz. It is likely that at least some “European” power converter/generator will be required. A list has recently been generated and sent of the required equipment to install proximity cryogenics. This list will be reviewed to determine if US substitutes can be procured. One exception is likely the highly specialized welding machines for the thin-walled inner membranes.

- Preparation of operation procedures is not included in the schedule. Per Barry Norris, these procedures will be prepared by the operations side of ND, not the project side. This approach is used to ensure consistency across ND operating areas.

- Responsibility for contracting and coordinating radiographic examination needs to be defined.

- No pressure test procedure has been agreed upon between CERN and FNAL for the cryostats. Demaco will be pressure testing proximity cryogenics per European standards for pressure vessels and piping. Using these standards is allowed per FESHM.

- The routing of 5 transfer lines for SBND has yet to be defined and had to be dropped from the current order with Demaco. Contract with GTT needs to be signed so that GTT can perform design study to determine where cryogenic feedthroughs are located.

- The gas filter specifications for NP01 have not been fully defined. Ongoing discussions between INFN and Fermilab.

- Proximity cryogenic control specifications have not been given to FNAL. FNAL is responsible for cryogenic controls equipment and programing. This document is expected to be delivered to Fermilab soon.

- Recent experience from ProtoDUNE has not yet been used to update SBN schedules.

Comments

- Placement of order and delivery of Protego valve should be schedule milestones.

- It remains unclear who is responsible for installing the "warm" proximity cryogenics supplied by CERN. Discussions have started but no decisions made. The responsible party for this task should be identified soon.
- The equipment list needed by contractors for installation should be carefully reviewed by CERN and FNAL to ensure that all necessary equipment is readily available for installation and that substitutions can be located.
- Management needs to be able to track progress so that operating procedures are ready in time. If not explicitly included in schedule, then consider using a method similar to one used for engineering notes. Time should be dedicated during the commissioning stage towards updating the procedures as experience is gained in using them.
- Fermilab regularly contracts with local companies to perform the necessary radiographic examination. Advance notice is required to prepare contract along with an estimate of the number of welds to be examined.
- Cryogenic controls groups are generally one of the last groups to be able to test their systems since they have to largely wait until installation is complete. Effort should be made to review controls logic and implement logic before installation is complete. This allows the cryogenic controls group to focus on quickly performing system check out after installation.
- Competition for engineering resources between the two SBN systems and with the LBNF & DUNE systems is likely. Neutrino Division will assist LBNF & DUNE but needs to hire new engineers to

ensure sufficient support for SBN and other ND projects. Coordination of engineering resources will require active effort to ensure all three cryostats receive the engineering resources necessary to avoid schedule delays.

- CERN wants Demaco to be able to work autonomously while at Fermilab. This is difficult, since there is a lot of work that needs to be completed by many different groups in a restricted space. Unclear how much the work of Demaco overlaps with the work of other groups in the area. A very active coordination effort will be required by Fermilab as the host to accommodate the many different groups working in the area.
- A large number of platforms and supports need to be installed prior to when Demaco arrives to install proximity cryogenics. FNAL has a 3-d model that includes the platforms and supports for proximity cryogenics. The model is undergoing updates based on feedback from CERN. FESS is actively working with ND. The final model and specifications for the platforms and supports should be carefully reviewed and documented. A lot of installation work needs to occur in a short time frame to be ready, so a lot of information needs to be transferred to many parties quickly and accurately.
- Write a lessons learned document for the ProtoDUNE cryogenics system, which has many similarities to the SBN cryogenics systems.
- Contact ProtoDUNE to obtain their lessons learned document. This would be very helpful input towards modifying the SBN schedule to make more realistic and accurate. Experience provides a good baseline for making schedule estimates.
- The time necessary to purify the system has some uncertainty and could be affected by the impurity levels delivered by the supplier. The time necessary to purify ProtoDUNE can be used to refine the purification time estimate. Purity levels of each shipment will be tested at FNAL. Consider getting samples from suppliers that can be tested for purity. Consider having the supplier regularly test purity at plant.
- The process of placing a contract for regular liquid cryogen deliveries typically takes close to 6 months at Fermilab from start to finish. The project already has RFI and is aware of options offered by commercial liquid cryogen suppliers. Process of generating RFQ should be started in the next couple months. May be dependent on fill time (see one row below).
- The planned filling time for ICARUS is undetermined. FNAL, CERN and INFN should finalize a plan as soon as possible. Scaling from INFN experience, filling may take as little as 2 weeks. Scaling from MicroBoone experience this process may take as long as 14 weeks. Filling time has a large effect on when the detector will be ready to start taking physics data. The planned fill time needs to be finalized soon so that accurate estimates of completion date can be determined.
- The overall quantity of documentation required for the engineering notes will be quite large, come from many different parties, and fall under both “US” and “European” standards used to satisfy pressure equipment regulations/directives. Fermilab has been actively updating FESHM to give clear requirements about using components and systems falling under EN standards. Engineers for SBN are participants in the safety subcommittees writing the white papers and updating FESHM. Contact safety subcommittees early and often when questions about using international standards at Fermilab arise.
- A large number of engineering notes will be required for safety review. A master spreadsheet will be used to track progress of all engineering notes. Management should regularly review this spreadsheet to ensure adequate progress is made in generating engineering notes.

- Engineering note reviewers may become overwhelmed by the large number of engineering notes delivered close to planned ORC date. Program will try to get necessary engineering notes to CSS SBN review panel with sufficient time to review prior to ORC. SBN engineers in regular contact with CSS SBN review panel chair. Contact CSS chair and CSS SBN review panel chair if a large number of engineering notes need to be reviewed simultaneously. Fermilab has a large pool of qualified reviewers if additional reviewers are needed.
- CERN plans to send proximity cryogenics components just in time for Demaco to do the inspection upon arrival at Fermilab. Having Demaco inspect the components upon arrival at Fermilab is likely to be helpful. However, if any component were to be damaged during shipment then it would be helpful to start the repair process as soon as possible. Johan noted that a transfer line segment had been damaged during shipment to CERN for storage. The same crates that were used for shipment to CERN will also be used for shipment to FNAL. Shock logger results were within acceptable levels. Carefully review shipping specifications, support system and crate design. Monitor shock loading during shipment.
- Time should be devoted to writing installation plans and Job Hazard Analysis in order for international collaborators and contractors are be able work efficiently soon after arrival at Fermilab. Similar documents have been written for the installation at CERN for ProtoDUNE. A copy of these documents should be made available and use to create JHAs and installation procedures.
- The SBN schedule review report should be compared to the existing risk registry and updated as appropriate. This comment is for the entire SBN program.

Recommendations

8. Determine the responsible party for installing the “warm” proximity cryogenics components delivered by CERN.

9. The pressure test procedure for the SBN cryostats should be written and agreed upon soon, otherwise this issue is likely to cause a delay during the safety review for ORC.

10. The planned fill time for the ICARUS cryostat needs to be determined soon, so that a contract can be finalized in time for the required deliveries of liquid argon. The fill time has a large effect on the overall schedule.

11. Incorporate lessons learned from ProtoDUNE into the installation of SBN cryostats. The ProtoDUNE experience should be used to update and refine SBN schedules.

12. Detailed written installation plans and job hazard analysis should be given to international collaborators & subcontractors prior to their arrival at Fermilab. To meet the schedule, these collaborators will need to work quickly and efficiently as soon as they arrive at Fermilab.

13. There are 5 transfer line sections that are not defined and cannot be defined until GTT completes the design study for the SBND cryostat. The design and fabrication of these transfer lines should proceed as quickly as practical to meet the installation schedule

14. The SBN project maintains a detailed risk registry. The risk registry should be compared to this review report and updated as necessary to accurately capture all known schedule risks.

4.0 Project Management

a. SBND Installation Schedule

Subcommittee: Dave Pushka, Jay Theilacker

Charge Questions:

Is the technically driven schedule and associated milestones complete, comprehensive and achievable with available resources?

Yes, for TPC assembly.

No, for installation.

The availability of required resources is not guaranteed, and key engineering individuals may be pulled away from SBND TPC assembly, leading to delays. SBND installation may be delayed due to cryostat availability.

Findings

- A Work Package Agreement document (SBN-doc-716) between collaborating parties was made available, but it is only in draft form. The version presented was dated November 30, 2016.
- It was mentioned that the project office is working with an import company to help foreign components clear customs.
- Detector components will come with QC measurements in a database that will be expanded with measurements taken upon receipt.
- Installation schedules were presented as relative schedules instead of absolute due to slipping of important milestones related to the detector design review that are required to proceed with important installation items such as hanging the TPC from the cryostat top plate.
- A detailed assembly plan (SBN-doc-5684) was presented.
- A detailed transportation plan (SBN-doc-5681) was presented.
- The cryostat top cap will be designed and built by CERN as two halves. Interfaces to the SBND installation was presented in SBN-doc-552.
- Floor preparation was presented in SBN-doc-4107.
- The photon detectors need to be the last installed in order to minimize exposure to UV radiation.
- Cable tray routing will be incorporated into the hall solid model to help minimize interferences.
- A critical path was not presented.
- Issues related to the start of the cryostat design study were presented and discussed in detail. We were told that once the cryostat design study starts, it will take about 14 months to complete cryostat design, procurement and installation and to have cryostat top cap ready for detector. The schedule

for completion of the TPC assembly at DAB is also about 14 months out. As a result, there will be a one to one gap buildup between TPC assembly completion and installation beginning now and when the GTT design study begins.

Comments

- The importance for having a customs plan in place ahead of time for all components coming from overseas should not be underestimated in order to avoid delays.
- Completing the Work Package Agreement document was a recommendation from the November 2017 review. There have been no edits to the document online since this review.
- Communication between the program and the SBND detector component collaborators appears to be good.
- We are pleased with the testing plans for the mockup APA frame assembly as well as the Assembly and Transportation Frame (ATF) test transport between DAB and SBN-ND.
- The cable tray and cable installation may need to be a fixed price contract due to the laboratory's desire to minimize T&M usage. This will require additional resources for developing the required drawings and specifications necessary for a fixed price contract.
- There is a concern of losing required resources due to the potential schedule gap that could develop between the TPC assembly completion and the cryostat availability. This would reduce the efficiency of available resources in the SBND Installation WBS.

Recommendations

15. Initiate the design review and fabrication of the Assembly and Transportation Frame as soon as possible to ensure that it does not delay APA and CPA installation

b. ICARUS Installation Schedule

Subcommittee: Dervin Allen, Jim Grudzinski

Charge Questions:

Is the technically driven schedule and associated milestones complete, comprehensive and achievable with available resources?

There is a technically driven schedule with associated milestones. However, the installation schedule is in process of being updated and identifies dates several months behind the current program schedule. This careful look at the installation schedule is a positive and should continue. That said, there have been delays in the recent major infrastructure tasks and several near term activities do not have fixed dates identified. A better understanding of the achievability of this schedule is needed.

Findings

- The installation schedule is being updated and is not currently reflected in the master schedule and currently indicates a further 3-month delay for milestone I-1 compared to the milestones posted in March.
- Current technician effort for the installation task is believed to be the proper effort but the group is currently made-up of temporary workers (three summer interns). One new permanent position has recently been approved.
- The current installation and commissioning plans assume that access to the top of the detector persists during the LAr fill.
- The scope of the installation coordinator ends before the installation of the Top CRT.
- Details of the commissioning activities were presented along with estimates of the required effort. The effort was estimated based on prior ICARUS installation at Gran Sasso.
- There currently are two weekly meetings between the installation coordinator, technical coordinators, and sub-system/working group leads which helps with coordination of resources and activities.
- SBN working groups are being formed and will participate in the development of a commissioning plan.
- Internal reviews are being held for the various sub-systems.
- The CRT has many aspects that can be performed in parallel allowing potential speed-up if delays are encountered.

- There has been a recent change at Fermilab related to how electrical work is completed requiring bid packages rather than simple time and material charging.

Comments

- Progress is being made in developing a detailed schedule and the project is encouraged to continue to this effort.
- A new installation coordinator has started work in the last two months and has made good progress coming up to speed and re-evaluating and updating the schedule.
- The team should consider reorganizing the installation related meetings for the purpose of improving efficiency and communication.
- The potential change in the way electrical work is carried out on site at a minimum adds delay to initiating work and the impact of this should be considered in the installation schedule.
- Continue to stay on top of the receipt of all documentation necessary for all safety and operational approvals so as to avoid delays due to the review process. This is particularly important for the cryogenic system which is being developed by multiple parties not familiar with FESH.
- The current state of interim technicians being counted on for the longer term installation should be addressed.
- The cryogenic installation is done by groups from CERN, Fermilab, and the contractor Demaco. This task requires careful coordination. It is recognized that the detailed installation plans for the cryogenic installation is not the responsibility of this installation team. It is suggested that more details of the cryogenic installation such as key activities and resources needed are added to the installation schedule with oversight by the installation coordinator. The detail necessary and purpose of this is to allow the installation coordinator to ensure that sufficient resources are available when needed and that there are not schedule/activity conflicts.

Recommendations

16. Resolve question as to whether there are any restrictions to accessing the top of the detector imposed by FESH during the LAr fill.
17. Reevaluate the scope of the installation coordinator with respect to the Top CRT.
18. The installation coordinator should continue to look carefully at the installation schedule and further develop detail. Add additional detail to arrive at a single overall master installation schedule that can be used to identify potential schedule conflicts.

19. Continue with the development of the commissioning plan and consider developing a resource loaded schedule of commissioning and integrate it into the master installation schedule to allow schedule tracking.
20. Proactively assist international collaborators in making arrangements to travel to the US well in advance of the needed arrival date to avoid delays.
21. Review the installation schedule in three months to reassess that milestones are achievable.

c. Integrated Schedule

Subcommittee: Rich Marcum, Mohammed Elrafih

Charge Questions:

Is the technically driven schedule and associated milestones complete, comprehensive and achievable with available resources?

Not yet; however, before the review, efforts were started to improve the Far Detector installation schedule, an these efforts are addressing many gaps in the current schedule.

Findings

- The SBN resource loaded Program schedule (RLS) attempts to contains all of the DOE funded Program scope; the non-DOE elements are largely missing.
- System schedule appears to be well defined for
    - Brookhaven SBND Electronics schedule which is not on the critical path.
    - DAQ/DCS which is independent of other systems.
- The current Icarus installation schedule has slipped approximately three months to date.
- The current integrated schedule is missing several interfaces including
    - ICARUS electronics coordination between TPC and PMT
    - Safety training for U.S. collegiate institution contributors
    - Argon fill time, which is a predecessor to final CRT installation and commissioning. The projected fill time varies from two weeks to fourteen weeks, but there is no detailed fill time shown on the schedule.
    - Restrictions to top access of vessel during a purge, fill, or testing are not identified, which could affect electronic installations and other activities.
    - Pre-commissioning and commissioning plans are not in the schedule because a detailed commissioning plan has not been formally developed.
- Logic errors were found in the schedule; for example, the ‘Filling Complete’ milestone completes before the ‘Ready for Filling’ milestone.

Comments

- The SBN Program teams were very cooperative and collaborative.
- Although the current RLS attempts to capture the complete work scope for the DOE funded activities of the SBN Program, it is not comprehensive as evidenced by missing coordination between several systems.
- The SBN Program could reduce schedule delay risks by understanding key handoff points and constraints. A more visible comprehensive schedule would provide great value to the Program. This visibility is particularly important to international partnerships and sub-contractor coordination. However, much of the daily coordination can be handled using other communication tools. All communication and coordination tools should be identified and used appropriately.
- The current schedules as presented may not be achievable, as there are too many gaps in the cryogenics and detector installation areas including
    - Logistics and timelines for providing international labor force at FNAL are often not accounted for in the schedule such as visa processing time
    - Safety training required for collaborating institution labor
    - Lead time to resolve Protego valve, which could take up to 40 weeks
    - Strain gauge delivery and installation delays
    - Procurement cycles or lead-times
    - Argon fill time, which is a predecessor to final CRT installation and commissioning. The projected fill time varies from two weeks to fourteen weeks, but there is no detailed fill time in the schedule.
    - Restrictions to top access of vessel during a fill, purge, or testing are not identified, which could affect electronic installations and other activities.
    - Pre-commissioning and commissioning plan timelines or milestones are not reflected in the schedule because a detailed commissioning plan has not been formally accepted.
    - Resource constraints with Engineering and Program Management Office coordination
    - Missing schedule coordination between systems
    - Tracking of document approvals
    - Date to execute the GTT contract for SBND Cryostat installation is unknown

- ICARUS electronics schedule needs documentation to demonstrate coordination between the TPC and PMT.
- SBND Program schedule should identify and incorporate more intermediate and coordination milestones
- Availability of engineering resources needs to be carefully monitored and make adjustments to the schedule as needed.
- Continue to focus on an integrated installation schedule to
    - Improve coordination between systems. All Systems should understand interface points and effects of plans on other systems.
    - Increase visibility of deliverables and provide better coordination between sub-system installations.
    - Ensure there are adequate milestones, including intermediate deliverables, to provide visibility of constraints, and coordination.
    - Ensure all non-catalog procurements are identified with adequate lead-times to facilitate successful deliveries.

Recommendations

22. Informed by the best practices of the CERN process model of the "Impact Statement", describe and document work scope to be performed, equipment requirements, performance needs, durations, etc. This process would be especially useful to understand the schedule impacts related to cryogenic system installation requirements (i.e. welding) and detector installation.
23. Using an appropriately tailored model for building and area coordination create a Responsibility Assignment Matrix to ensure that the appropriate individuals take ownership for identifying and planning work including handoff activities.
24. Ensure Program management office has adequate labor resources to support schedule development efforts.
25. Regularly verify Program schedule critical and near-critical paths including deliverable dates from collaborating institutions.
26. Formalize the commissioning plan and reflect this in the Program integrated schedule via milestones as well as logical interactions i.e. predecessor/successor relationships, especially for cooldown, filling, and commissioning efforts.

d. Management

Subcommittee: Gina Rameika

Charge Questions:

Is the program being properly managed for the successful execution of the SBN?

There is a strong management team in place dealing with a very complex organization of partnerships and collaborations. The committee feels that the management team could benefit by being augmented with someone dedicated to strategic planning of the tasks required to meet milestone I-1 and I-2.

Are the projected personnel resources sufficient to complete design, construction, installation and commissioning of the SBN program and are these resources likely to be available when needed?

There is concern that the source of the resources needed to execute all aspects of the installation of the cryogenics is not clearly identified, though there is good communication started and this should be resolvable in the near future.

Are the remaining significant risks understood and adequately managed?

Yes, the risks are recognized and managed; however, new risks are being identified as the work moves forward and constant vigilance is required.

Is the boundary between construction/installation and commissioning well defined?

The boundaries are understood, though there are overlaps which may make the boundaries seem fuzzy. For example, detector commissioning must take place prior to the installation of the CRT and shielding on top of the detector.

Are the resources needed for initial ICARUS operations understood and identified?

The needed resources, in particular scientific staff (post-docs and students) coming from the collaboration are understood and can be realized if adequate funding for support of long term stays at Fermilab can be realized.

Is ES&H being appropriately addressed? Are the required safety approvals on-track to meet the schedule?

Yes. The program teams are fully invested in integrated safety management. The time and tasks required for completing safety approvals is built into the schedule. The plan for testing and acceptance of the far detector cold vessels remains to be approved.

Findings

- Inconsistencies in the dates of the key milestones were presented in various presentations and the main project resource loaded schedule (RLS).
- Using the resource loaded schedule for construction as well as understanding of the post construction/installation tasks the program management has produced conservative, technically driven dates for meeting each of the key milestones.
- There is significant scope, in particular that covered by non-DOE partners that is not detailed in the program schedule and therefore, there are inconsistencies in the dates when tasks are expected to start and complete.
- A list of specific tasks and accomplishments which are needed to meet each of the key milestones has been developed.
- A detailed weekly work list is maintained by the Far Detector installation manager.

Comments

- Since the last review the SBN team has made good progress in defining the scope of work needed to meet the key milestones.
- Good progress is being made on the tasks needed to be completed in advance of rigging the ICARUS-T600 vessels into the far detector building.
- Several U.S. groups are requesting effort and support in the installation and commissioning of the ICARUS detector. These needs should be discussed with the program as soon as possible, so that arrangements can be made in a timely manner.

Recommendations

27. Based on the task lists that are associated with each of the key milestones, establish clearly defined and reasonably spaced **intermediate milestones** to lead to each of the key milestones.
28. Monitor the intermediate milestones monthly. Milestones that are forecasted to be missed should be documented with an explanation and an updated forecast for completion submitted to the Program Manager.
29. Develop a detailed plan for the needs of the U.S. University groups that want to participate in Far Detector (ICARUS-T600) installation and commissioning that can be submitted to DOE.
30. The program should incorporate both major tasks and intermediate milestones for the ICARUS front-end electronics installation and commissioning into the master installation schedule for ICARUS. This should be coordinated with the proponents. Interdependencies should be identified, and potential interferences with other activities be resolved.

31. Integrate the SBND TPC installation plan with the overall near detector installation plan so that all overlaps are identified and scheduling conflicts avoided.

32. Update the risk register.

33. Updated schedules, for both the far and near detectors that extends through completion of the key milestones should be prepared before the next review.

34. Plan for a follow-up cost and schedule review in the Fall 2018.

Appendices

A. Charge

B. Agenda

C. Review Committee Contact List and Writing Assignments

Appendix A

Charge

Fermi National Accelerator Laboratory

Date: **April 23, 2018**

To: Bob Tschirhart, Chief Project Officer
From: Nigel Lockyer, Director
Re: Director's Progress Review of the Short Baseline Neutrino Program

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Message:

Please organize and conduct a Director's Review on June 26th – 27th, 2018 to assess the progress of the Short Baseline Neutrino Program. This review should focus on the technically driven schedule of the following program elements:

- Installation of the ICARUS detector;
- Design, construction, and installation of the ICARUS cosmic ray tagger;
- Design, construction, and installation of the SBND detector system (TPC, cosmic ray tagger, light collection, electronics, DAQ) and its cryostat;
- Design, construction, and installation of the necessary support infrastructure such as cryogenic systems, DAQ and overburden;
- Commissioning plan

The focus of this review is the forecast for completing installation of ICARUS and SBND in the context of a technically driven schedule. Topics will include schedule, management, ES&H, and technical readiness to execute the remainder of the SBN program. The review committee should respond to the following questions:

1. **Construction, Installation and Commissioning.**

   a) Is the overall progress on ICARUS installation, cryogenics, construction and commissioning consistent with the planned milestones? Is the process for establishing milestones sound and tractable? Are appropriate program driven technical reviews being planned, conducted and responded to? Are interfaces being adequately addressed?
   b) Is the overall progress on SBND installation, cryogenics, construction and commissioning consistent with the planned milestones? Is the process for establishing milestones sound and tractable? Are appropriate program driven technical reviews being planned, conducted and responded to? Are interfaces being adequately addressed?

2. **Technically driven construction and installation schedule**.

   Is the technically driven schedule and associated milestones complete, comprehensive and achievable with available resources?

3. **Management.**

   Is the program being properly managed for the successful execution of the SBN? Are the projected personnel resources sufficient to complete design, construction, installation and commissioning of the SBN program and are these resources likely to be available when needed? Are the remaining significant risks understood and adequately managed? Is the boundary between construction/installation and commissioning well defined? Are the resources needed for initial ICARUS operations understood and identified?

4. **Environment, Safety, and Health**.

   Is ES&H being appropriately addressed? Are the required safety approvals on track to meet the schedule?

The committee is asked to present a draft of their report at the review closeout and to issue the final report within three weeks of the review's conclusion.

Nigel S. Lockyer
Director of Fermilab

Appendix B

Agenda

Director's Progress Review of the Short Baseline Neutrino Program
June 26-28, 2018

Wilson Hall (WH), Fermi National Accelerator Laboratory

Tuesday, June 26, 2018

Time	Session	Location	Speaker
08:00	Executive Session	Comitium – WH2SE	Gina Rameika
08:30	Plenary – Welcome	One West – WH1W	Joe Lykken
08:40	Plenary – SBN Overview	One West – WH1W	Peter Wilson
09:30	Breakout Sessions (see below)		
10:30	Breakout Coffee Break	Comitium Alcove– WH2SE	
10:45	Breakout Sessions		
12:00	Lunch	15th Floor Crossover	
13:00	Tour of ICARUS	Bus from front of WH	Catherine James, Claudio Montanari, Aria Soha
14:30	Executive Session	Comitium – WH2SE	Gina Rameika

BREAKOUT 1 – ICARUS Electronics – Location: Virtual Reality – WH3SE

Time	Session	Speaker
09:30	TPC Electronics (incl cables, feedthroughs)	Alberto Gugliemi
10:00	PMT Electronics and Calibration	Gian Luca Raselli
10:45	Discussion	

BREAKOUT 2 – SBND Electronics – Location: OPSSession – WH2SE

Time	Session	Speaker
09:30	Cold Electronics	Hucheng Chen
10:00	SBND TPC Back-end Electronics	Jose I. Crespo-Anadon
10:45	Discussion	

BREAKOUT 3 – Common Online – Location: One East – WH1E

Time	Session	Speaker
09:30	Common Online	Kurt Biery
10:00	ICARUS Specific	Wesley Ketchum
10:45	SBND Specific	William Badgett

BREAKOUT 4 – ICARUS Installation – Location: Snake Pit – WH2NE

Time	Session	Speaker
09:30	Installation Schedule	Aria Soha
10:00	Infrastructure for ICARUS	Catherine James
11:00	Collaboration Resources	Claudio Montanari

BREAKOUT 5 – SBND Detector and Cryostat – Location: Comitium – WH2SE

Time	Session	Speaker
09:30	SBND TPC Components Fabrication	Kostas Mavrokoridis
10:00	Cryostat Design and Fabrication	Marzio Nessi
10:45	WBS 2.4: PMT-PDS Status	Richard Van de Water
11:15	WBS 2.5: CRT and LCS	Igor Kreslo
11:45	Discussion	

BREAKOUT 6 – SBND Installation – Location: Black Hole – WH2NW

Time	Session	Speaker
09:30	SBND Assembly	Juan Estrada
10:00	Cryostat Installation Preparation	Min Jeong Kim
11:00	Discussion	

BREAKOUT 7 – Cryogenics – Location: Director's Conference Room – WH2E

Time	Session	Speaker
09:30	ICARUS Proximity Cryogenics	Johan Bremer
10:00	WBS 4.03 Cryogenic Systems – ICARUS and SBND	Michael Dinnon
10:45	SBND Proximity Cryogenics	Johan Bremer
11:15	SBND External Cryogenics, Controls and Integration	Michael Dinnon

Wednesday, June 27, 2018

Time	Session	Location	Speaker
08:30	Breakout Sessions (see below)		
09:30	Breakout Coffee Break	Comitium Alcove– WH2SE	
12:00	Lunch	15th Floor Crossover	
13:00	Tour of SBND Assembly	Bus from front of WH	Juan Estrada
14:15	Executive Session	Comitium – WH2SE	Gina Rameika

BREAKOUT 4 – ICARUS Installation – Location: Snake Pit – WH2NE

Time	Session	Speaker
08:30	Answers to questions	
09:00	ICARUS Cosmic Tagger (Sides)	Anne Schukraft
09:45	CRT Top	Umut Kose
10:15	Transition to Commissioning	Angela Fava, Claudio Montanari
10:45	Discussion	

BREAKOUT 6 – SBND Installation – Location: Black Hole – WH2NW

Time	Session	Speaker
08:30	Answers to questions	
09:00	Cryostat Installation	Min Jeong Kim
09:45	TPC Installation	Juan Estrada
10:15	CRT Installation	Igor Kreslo
10:45	Discussion	

BREAKOUT 7 – Cryogenics – Location: Director's Conference Room – WH2E

Time	Session	Speaker
08:30	Answers to questions	
09:00	Overflow from Tuesday	Min Jeong Kim

Thursday, June 28, 2018

Time	Session	Location	Speaker
09:00	Executive Session	Comitium – WH2SE	Gina Rameika
11:00	Closeout	One West – WH1W	Gina Rameika

Appendix C

Review Committee Contact List and Writing Assignments

Director's Progress Review of SBN
June 26-28th

Chairperson:

Gina Rameika rameika@fnal.gov 630-840-2262

Integrated Schedule :

Rich Marcum, FNAL	rmarcum@fnal.gov	630-840-8236
Mohammed Elrafih, FNAL	melrafih@fnal.gov	630-840-8697

Icarus Front-End:

Michelle Stancari, FNAL	mstancar@fnal.gov	630-840-4953
Gary Drake, ANL	drake@anl.gov	630-252-1568

SBND Front-End:

Dave Christian, FNAL	dcc@fnal.gov	630-840-4001
Pam Klabbers, FNAL	pamela@fnal.gov	630-252-8704

Common DAQ, slow controls & Monitoring:

Jim Patrick, FNAL	patrick@fnal.gov	630-840-2626
Ryan Rivera, FNL	rrivera@fnal.gov	630-840-5012

SBND Detector & Cryostat:

Bruce Baller, FNAL	baller@fnal.gov	630-840-2427
Don Mitchell, FNAL	dmitchel@fnal.gov	630-840-4166

SBND Installation Schedule:

Dave Pushka, FNAL	pushka@fnal.gov	630-840-8767
Jay Theilacker, FNAL	theilacker@fnal.gov	630-840-3238

Icarus Installation Schedule:

Dervin Allen, FNAL	dervin@fnal.gov	630-840-2511
Jim Grudzinski, ANL	jjg@anl.gov	630-252-344

External and Proximity Cryogenics:
(Breakout hosted at CERN)

Jack Fowler Duke	fowler@phy.duke.edu	919-660-2562
Mike White FNAL	mjwhite@fnal.gov	630-840-6858

Observers:

Kevin Flood, DOE/HEP	kevin.flood@science.doe.gov	301-903-4829
Paul Philp DOE/FSO	paul.philp@science.doe.gov	630-840-4481
Simona Rolli, DOE/HEP	simona.rolli@science.doe.gov	301-903-0504
Glen Crawford, DOE/HEP	glen.crawford@science.doe.gov	301-903-4829

Closeout remote participants:

Eckhard Elsen, (CERN)
Antonio Ereditato, (Bern)
Antonio Masiero, (INFN)
Tony Medland, (STFC)