Fermilab

Final Report

Director's Progress Review of SBN

November 1-2, 2017

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1.0 Executive Summary

Fermilab is the host Laboratory to the international Short Baseline Neutrino (SBN) program located on the Neutrino Campus and using the Booster Neutrino Beam (BNB).

The program has both scientific and technology goals. The main scientific goals of the program are to search for neutrino oscillations, achieving 5σ coverage of the LSND signal and global best fit region of parameter space, and to collect a large data set of ν-argon interactions for cross-section measurements. The technology goals are to further develop detector designs for construction and operation of liquid argon time projection chambers (TPC) and their read-out so as to inform and refine the detector development for the Deep Underground Neutrino Experiment (DUNE).

The first SBN detector operating and collecting data for the program is the MicroBooNE detector located 470 meters from the BNB target. MicroBooNE began operation in 2015 and to date has collected greater than $6x10^{20}$ protons on target.

Two additional detectors are to be added to the program : the T600 ICARUS detector will be located at 600 meters from the target and the Short Baseline Near Detector (SBND) will be located at 110 meters from the target. At the present time each detector is managed by an independent collaboration and there are a number of funding sources supporting the efforts.

The ICARUS detector, which operated in the Gran Sasso Laboratory from 2010 - 2014, was transported to CERN in late 2014 where it was refurbished under a joint agreement between CERN and INFN. In 2017 it was transported to Fermilab under that same agreement. The remaining work to install the detector and cryogenics is a joint effort between CERN, INFN and FNAL.

The SBND is a new construction effort funded by DOE, NSF, UK-STFC, CERN, INFN and the Swiss National Science Foundation.

The status of adding these two detectors into the program was the focus of the November 1-2, 2017 Director's Review described in this report. The primary emphasis of the review was to focus on the DOE-funded Scope of Work and to understand how the interfaces with the non-DOE scope were affecting the schedule for completion and the DOE cost to complete.

The SBN Program DOE funded Scope of Work is divided into a Construction Phase and an Operations Phase. The Construction Phase includes :

- design and construction of new buildings to house the ICARUS and SBND detectors
- design, construction and installation of common infrastructure for both detectors, including parts of the cryogenic systems
- installation of the ICARUS detector
- design, construction and installation of parts (sides and bottom) of the ICARUS cosmic ray tagger
- assembly and installation the SBND TPC

The Operations Phase includes :

- Transition to operations including reviews and approvals for Operational Readiness Clearance
- Liquid argon filling for ICARUS (late CY2018) and SBND (CY2020)
- Detector commissioning, operations, data taking and analysis

In this review the focus was primarily on construction activities and the transition to operations.

The review committee noted that over the past year there has been good progress in most areas of the Program however there are a number of concerns.

The primary concern is the uncertainty on the cost to complete the DOE-funded scope of work. In December 2016 the cost estimate for the DOE-scope (not including the GPP-funded infrastructure) was $20M ; in September 2017 the estimate was $29M. The committee notes that during this period a major effort was put into capturing the full scope of work and establishing a cost baseline (completed in May 2017).

A second area of concern is also related to costs and funding. The committee was shown an obligation profile derived from the resource loaded schedule which exceeds the available/planned funding by several million dollars in each year of FY18, FY19 and FY20. A proposal which defers obligations into the succeeding year was shown and discussed, but the implications on the SBND construction completion time are not favorable.

The committee notes that there are several technical areas of concern that have impact on the program schedule. The first is in regard to the installation of the ICARUS detector and the cryogenic system. The cryogenic system installation cannot begin until the cold vessels have been installed into the warm vessel. The cold vessel installation requires three outstanding tasks or issues to be resolved : 1) delivery and installation of the cold nitrogen shields, scheduled to be complete in March 2018; 2) a rigging plan, which may require an upgrade of the building cranes, needs to be approved by all stakeholders; 3) an agreed upon testing plan for the cold vessels which meets FESHM requirements.

The second main technical area is in regard to the construction schedules for the SBND TPC and electronics. TPC construction in both the UK and the US is behind schedule by many months compared to the schedule presented at the December 2016 review. There are a number of reasons in each case and the teams are now working to very aggressive schedules to compensate for the delays. The design of the cold electronics, which currently is based on successful testing of a commercial-off-the-shelf (COTS) ADC is also very aggressive and needs to be monitored carefully.

The committee feels that the Program management now has tools in place which will help them better determine the cost to complete and aid in tracking progress against the baseline, and recommends that a detailed review of cost and schedule be held in about 6 months time.

Finally, the committee notes that the international neutrino community views the SBN program as an important stepping stone in the neutrino program at Fermilab, ultimately leading to DUNE. Significant investments have already been made by our partners from CERN, INFN, NSF, Switzerland and UK-STFC. They plan on additional investment to complete the installation of ICARUS and construction of SBND. These partners are relying on Fermilab as host Laboratory to expeditiously bring the SBN program into operation to ensure that these international investments are utilized.

2.0 Introduction

A Director's Progress Review of the Short Baseline Neutrino (SBN) Program was held on November 1-2, 2017 at Fermilab. The focus of this review was to assess the cost, schedule, management, ES&H, technical readiness and overall progress of the SBN Program.

2.0 Technical

2.1 Electronics & DAQ

Subcommittee: David Christian, Ted Liu, and Gary Drake

Charge Questions:

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

  Maybe. The schedule for SBND electronics and DAQ design, testing, and production looks very tight, but possible, especially if the COLD COTS ADC option proves viable.

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

  Yes.

- Are interfaces being adequately addressed?

  Maybe. We did not have time to understand the status of planning for most of the interface aspects of the SBND DAQ. The details of the readout of SBND electronics depend on a decision of where the ADCs will be located.

Findings

- The schedule calls for TPC cold electronics to be at FNAL ready for installation on January 7, 2019 and for the detector to be ready for transport to the ND building on April 1, 2019.
- The FY18 budget for the SBND electronics is still in flux.
- The SBND group started cold tests of COTS ADCs early in 2017. A number of COTS ADCs were identified that are able to operate at LN2 temperature.
- A version of the 128 channel Front End Mother Board (FEMB) using a COTS ADC was designed and produced and noise measurements (both warm and cold) were made using this board.
- SBND has developed a procedure to validate COTS ADCs for use in liquid argon. A note dated July 23, 2017 by Chen & Radeka (SBN-doc-3071) documents the planned study, which is divided into three phases. These are a preparation phase, an exploratory phase, and a validation phase.
- During the preparation phase, more than 100 of each of three COTS ADCs were tested at LN2 temperature, warmed to room temperature, and cooled back to LN2. For all three candidate ADCs, the cold yield was 100%.
- The preparation phase of the COTS ADC study has been completed. In this phase the performance of three COTS ADCs was compared at room temperature and at LN2 temperature. The measurements show that one of the three candidate ADCs had worse differential nonlinearity at LN2 temperature than at room temperature. This candidate was eliminated from the study. The other two ADCs performed slightly better at LN2 temperature than at room temperature.

- The exploratory phase is ongoing. During this phase, individual COTS ADC samples were stressed by applying higher than normal bias voltage while at LN2 temperature, warming to room temperature, and cooling back to LN2 for performance characterization. This cycle was repeated a number of times, with the stress voltage being applied for a longer period of time each cycle. One COTS ADCs performed well after more than 30 hours in the exploratory phase, with no significant increase in current drawn and no significant increase in differential nonlinearity.
- The validation phase of the study will follow the exploratory phase. The goal of this phase is to validate the results of the exploratory phase.
- A cold electronics production readiness and safety review is scheduled for August 2018.
- The SBND group plans to use the 40% APA cold test system at BNL to measure the noise performance of cold electronics.
- The group is also discussing the possibility of doing a vertical slice test using the LArIAT cryostat and TPC. The existing TPC matches the SBND wire pitch and gap between wire planes.
- Both the SBND and the ICARUS TPCs use 3mm wire spacing for the anode planes with 3mm between planes of wires. The SBND group plans to digitize the TPC anode signals at 2 MSPS. The ICARUS group plans to digitize the TPC anode signals at 2.5 MSPS.

Comments

- The test data from COTS ADCs look very promising.

- We believe a prototype Front-end mother-board using COTS ADCs can be produced by the end of November.

- We believe that it is important that system-level testing of cold electronics and DAQ elements using the 40% APA test stand at BNL and LArIAT be conducted before production readiness reviews are held.

- We urge the SBN collaborations to consider using the same digitization frequency for near and far detectors.

Recommendations

1. Proceed without delay with the design and testing of a 128-channel FEMB using one of the two COTS ADCs currently in the validation stage of evaluation. This will allow a wider range of test results to become available sooner.

2.2 Detector

Subcommittee: Bruce Baller, Dervin Allen, Michelle Stancari

Charge Questions:

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

  Yes. There has been good progress on both construction and installation planning for both ICARUS and SBND. For SBND, APA construction is a concern because it is behind schedule and the current schedule for completion is very aggressive.

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

  Yes. Design reviews of various SBND TPC components have been completed in a timely manner. The collaboration has completed reviews which include the PMT mechanical installation, wire winding design (UK & US) and a wire winding readiness review in the UK. Planned reviews include a readiness review of the field cage before construction in Q1-2018, a DAQ & Trigger review of the PDS system and a US wire winding readiness review.

- Are interfaces being adequately addressed?

  Yes. Interfaces between TPC subsystems are identified and reconciled during weekly coordination meetings. The master 3D model, maintained at Fermilab, is regularly updated.

Findings

- The ICARUS CRT installation plan is sensible and is on schedule. Mechanical installation for the side CRT has been strategically decoupled from the readout installation, allowing the decision on the readout design for the side CRT to be delayed to February 2018.
- Construction of the SBND-APA frames would have been completed on schedule were it not for a machining error.
- For SBND-APAs, wire winding at Yale has not started yet due to the unavailability of the facility. The schedule shows a wire winding review occurring in December 2017 which is only one month after the currently scheduled occupancy of the facility.
- The SBND CRT and laser calibration systems (BERN) are on schedule and well ahead of the critical path. These designs are largely based on similar systems at MicroBooNE.
- Progress on the SBND Photon Detection System is significantly advanced compared to last year. This system is well ahead of the TPC construction schedule. The LANL LDRD funding for M&S ends in FY2018.
- The APAs are scheduled to be delivered to FNAL on May 10, 2018 (UK) and August 8, 2018 (US).
- The UK-STFC funds for SBND APA construction, wire winding and shipping must be spent by April 2018. Funds for scientific effort and travel have been secured through end of 2019.

- The plan for SBND detector installation and integration currently includes channel mapping and verification of connections but does not currently include a vertical slice test of the integrated system and evaluation of detector noise levels.

Comments

- Technical reviews of ICARUS installation were performed in the last year. The coordination of installation activities among different contributing institutions is challenging and is being done well.
- The construction schedule for the SBND-TPC components is achievable but aggressive. In particular, the wire winding is many months behind the schedule presented last year and late delivery of the APAs will impact downstream schedules.
- The SBND TPC QA/QC procedures and acceptance criteria for all APA components should be identical without regard for the construction facility.
- There are three separate SBND construction activities at Yale; wire winding, field cage construction and HV feedthrough. It may be a challenge to coordinate and adequately supervise students in all areas.
- The current schedule places final integration tests and checkout of the SBND detector at the end of 2019. Should there be additional schedule delays, the source of funding for travel of TPC experts to participate in these activities in 2020 needs to be identified.
- Because the SBND LANL-LDRD PDS M&S funding ends in 2018, premature decisions on installation hardware and components could lead to additional integration costs.
- A vertical slice test for SBND is important to ensure adequate detector performance. This will inevitably take some time and require the participation of detector and electronics experts.

Recommendations

2. Develop and review detailed installation plans for SBND assembly work at DAB and at the SBN-ND site prior to starting installation activities. These plans should include testing and acceptance criteria for each stage. Ensure that a formal sign-off procedure is in place for the final testing at SBN-ND before welding the cryostat top plate. The sign-off should include all sub-system managers and collaboration management.
3. The program office should evaluate the cost and schedule impact of late APA delivery.

2.3 Infrastructure

Subcommittee: Jim Grudzinski, Russ Rucinski, Bill Soyars

Charge Questions:

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

  Yes, however there are several areas of concern. The buildings for both detectors have been completed on schedule. The electrical outfitting is on schedule. The panel feels the SBN-FD schedule for commissioning the ICARUS detector is aggressive. It is important to note that

installation of the proximity cryogenics cannot begin until after the cold vessels are installed in the SBN-FD building..

The SBND APA production schedule is 8 months behind the schedule presented last December.

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

  Yes. Partial Operational Readiness Reviews are conducted for all electronics. Reviews are being carried out for cryogenics systems including reviews required to determine that FESHM requirements are met.

- Are interfaces being adequately addressed?

  Yes. Interfaces have been identified and are actively managed. The use of interface documents has started. Many documents remain to be created and/or signed off by all parties.

Findings

- SBD Near and Far Detector buildings have been completed to beneficial occupancy on schedule and within budget. The Site Development project is closed. Some experiment specific outfitting remains to be completed.

- The Fermilab scope of work for cryogenics has expanded to include scope previously thought to be in the CERN scope. This includes a filter for the SBND system and two purity monitors.

- Four critical tasks are required for moving forward with the FD cold vessel and cryogenic system installation. These are 1) delivery and installation of the cold shields into the warm vessel ; 2) completion of the structural evaluation and testing of the cold vessel, per FESHM; 3) development and review of an installation plan; 4) award of a rigging contract for the vessel installation, which may require an upgrade of the building cranes.

- The expected schedule for delivery of the ICARUS cold shields is March 2018.

- In the Program schedule, the cold vessels are scheduled to be installed in May 2018.

- In the Program schedule, the approval for cold commissioning of the vessels and cryogenics is scheduled for the end of calendar year 2018.

- The Fermilab and CERN cryo teams have been working with the cryogenic vendor via frequent communication and reviews. Four design reviews were completed monthly between July and October 2017. Weekly interface meetings are being conducted for proximity cryogenics.

- There is not yet an agreed to plan for installing/rigging the ICARUS detector. A rigging contract for moving the ICARUS vessels into the building was let and proposals received by FNAL two weeks ago. Technical evaluation of the proposals was just beginning at the time of this review. The

conceptual plan mentioned for moving the vessels was to use the two building cranes to move the cold vessels into the warm structure. This would involve "cantilevering" the vessel over the pit to enable the far crane to be able to pick up the vessel.

- There is a management risk, SBN-PM-012 that engineering documentation, analysis and testing plan of the ICARUS cold vessel structure is insufficient to pass the Fermilab Operational Readiness Clearance.

- The ICARUS T600 cold vessels are low pressure vessels designed by CERN and INFN which are fabricated using custom aluminum extrusions. The design uses the methodology of European standard EN13445 which is accepted as equivalent to ASME within the FESHM. Fermilab practice under FESHM requires an independent review of the design and a testing plan that validates performance leading up to Operational Readiness Clearance.

- Although a detailed testing plan has yet to be agreed upon by the stakeholders, preliminary vacuum tests have been successfully completed on both vessels at CERN. Eurocode EN13445 states that qualification of vessels requires a pressure test.

- The Fermilab required documentation for the ORC has not yet been prepared. For the ICARUS system, this includes the piping engineering note for the nitrogen cold shield that is currently being fabricated.

Comments

- The panel is concerned about the feasibility, cost impact and schedule impact of rigging the cold vessel into the warm structure.

- The FD cryogenic components from the vendor Demaco are scheduled to be completed and delivered to CERN and then Fermilab in advance of the readiness of the facility to install them.

- The panel feels the SBN-FD schedule for commissioning the ICARUS detectors is aggressive. We believe that installation of the proximity cryogenics, which cannot begin until after the cold vessels are installed, will take longer than planned. Structural support for the proximity cryogenics is not yet finalized.

- Reviews do not consistently appear as scheduled Milestones. Major testing does not appear as schedule Milestone.

- For mechanical and electrical outfitting, project side reviews that have occurred are not as formally captured as the FESS and ESHQ review processes were before bidding the work.

- For both detectors, some uncertainties remain in the plan for installation of warm piping.

- The SBND work package for Fermilab includes the internal cryogenics, the external cryogenics and the controls systems. The Protega valve is part of the internal cryogenics scope. The SBND work

package for CERN covers the proximity cryogenics. The proximity cryogenics includes the main circulation pumps and the penetration exhausts.

- SBND Cryogenic interfaces between FNAL and CERN are potential concern due to multiple revisions in scope.

- We heard that there is consideration of the ND cryostat top plate to be split into two parts for shipping. A milestone date should be set for determining ND top plate design.

- For SBND, the program Integration Engineer estimates the weight of the assembled roof cap and detector at 19.9 tons. This is very close to the SBND building crane of 20 tons. This is too close and needs to be mitigated.

- For SBND, the clearances to get the detector assembly out of the D-Zero Assembly building door are very tight (inches or less). This requires attention.

- For both detectors, cryogenic installation involves multiple components to fit into tight spaces. The sequence of installation of the components including CRT panels needs to be planned out. We heard that the final sizes of the valve boxes for SBND have increased recently.

- The Interface management plan presented for SBND is a good approach to capturing and controlling interfaces. The process of communicating changes in the interfaces requires manual action and has potential to not be communicated to all relevant parties.

- Electrical Outfitting work is well understood. The ground monitor effort for both detectors is completed except for installation, and Fermilab technical resources are available for installation and checkout at the FD building. The ND Building installation has not been as precisely scheduled yet.

Recommendations

4. Program management should work with all involved stakeholders to reach agreement on a testing plan to meet FESHM and EN13445 requirements as soon as possible, and prior to start of vessel installation.

5. All stakeholders should agree to a plan for rigging the ICARUS cold vessels as soon as possible.

6. Prior to cryogenic system installations, for both ICARUS and SBND, conduct a technical integration review. Allow time in the installation schedule for this.

7. Perform a thorough analysis of the mass budget for the SBND assembly that needs to be rigged with the 20 ton SBN-ND building crane. Create a rigging plan including the heights required for rigging equipment for this operation.

8. Create individual DocDB entries for each SBND interface document and utilize the document approval feature of DocDB in order to provide change control of interfaces as well as enhance communication of changes in interfaces.

3.0 Project Management

3.1 Cost and Schedule

Subcommittee: Rich Marcum, Corinne Vendetta

Charge Questions:

- Are the cost and schedule basis of estimates for remaining DOE-funded work credible?

  Not yet. The SBN estimates were based on past experiences from other projects and programs. However, based on past performance relative to these estimates, the estimates to complete should be revisited. See recommendations.

- Given the presented funding scenarios, is the SBN construction and installation schedule achievable?

  No. The SBN Program Coordinator showed a proposed funding plan that requires an additional 1M$ per year in FY19-21 compared to the current lab plan. The proposed plan also pushes SBND obligations out into FY2021, which is a year later than the collaboration's goal for completion of construction and installation.

- Are the schedules for the non-DOE deliverables compatible with the construction and installation schedule?

  Not sure. Based on technical reviewers input, the delivery schedules for both DOE and non-DOE deliverables need to be examined and confirmed, to ensure accurate development and tracking of the resource loaded schedule for the DOE scope.

Findings

- SBN uses Microsoft Project for their schedule tool.
- The MSP schedule has 1784 activities including milestones.
- The MSP schedule is resource loaded and logically tied with predecessor/successors.
- Variance Analysis has been performed for the last 2 months.
- SBN uses Deltek Cobra for the cost processing tool.
- Fermilab's FY18 overhead rate changes will add $200k to the cost estimate.
- No definitive critical path was presented.

- The 40SBN element in Lab project accounting includes costs beyond what are included in the SBN Program accounting.

- At the December 2016 Director's review, SBN scheduled costs were $20,078k, and as of September 2017 they are $28,951k.

Comments

- In the last year, the program has made great strides in developing the schedule, however, there is still significant effort needed to be able to understand the impacts of potential funding shortfalls which can impact the ability to meet technically driven milestones.

- L2 and Program Managers are using the schedule as a tool to help them understand their work priorities.

- The program management has been focusing on comparing actual costs versus budget whereas it may be more useful to focus on performance versus budget.

- The program has begun using the Earned Value metrics of CPI and SPI enabling them to perform Variance Analysis. These actions should help the program management and L2 managers better manage their budgets and schedules.

- The L2 managers should consider use of these quantifiable Performance Measurement Techniques during system status meetings.

- SBN should perform a monthly Estimate to Complete analysis, which will help better manage the cost and schedule as well a develop funding requests for the remaining work.

- For future review presentations, consider how the program can clearly distinguish cost and budget for experimental operations vs. those for elements included in MSP.

- SBN and protoDUNE/DUNE interfaces are not captured in the schedule, but do have potential impact on performance. The SBN management should consider ways to incorporate these into work planning.

Recommendations

9. For the DOE-funded Program scope, perform a bottoms-up Estimate to Complete (ETC). A clear definition of completion should be developed for each detector.

10. For the DOE-funded Program scope, refine and document the use of quantifiable Earned Value Performance Measurement Techniques to aid in tracking progress against the baseline cost and schedule.

11. Continue to use and improve project management analysis tools such as Variance Analysis Reports, Cost Performance Reports, and Corrective Action analysis.

12. Work with international partners to reconcile timelines for receipt of deliverable and determination of the non-DOE resources required for detector installation and commissioning.

3.2 ESH&Q

Subcommittee: Dave Mertz

Charge Questions:

- Is ES&H being appropriately addressed?

  Yes. Program personnel have demonstrated an awareness of environmental, safety, and health requirements in the presentations they gave in the breakout sessions. The particular hazards associated with liquid argon (LAr) detectors with beryllium-containing components have already been defined by the work on previous LAr detectors as well as methods for successfully mitigating them.

- Are the required safety approvals on track to meet the schedule?

  Yes. The two facilities that will house the SBN Near and Far Detectors have been completed and received final approval for occupancy in compliance with Fermilab standards and procedures. The permitting for experimental equipment has begun with the preliminary Operational Readiness Clearances completed for six subsystems, though this is only the beginning of the Operational Readiness Clearance (ORC) process. L2 and L3 personnel appear well aware of the ORC process and how to effectively utilize it. The efforts to establish safety equivalencies for electrical, mechanical, and structural codes to which in-kind equipment is constructed and the codes applicable to Fermilab sites have already delivered results that will greatly expedite approvals of this equipment, and remaining efforts appear promising.

Findings

- Facilities and equipment installed at Fermilab must follow the Fermilab Environmental, Safety, and Health Manual (FESHM) requirements and the Work Smart Standards which are part of the contract between the United States Department of Energy (DOE) Fermi Research Associates (FRA). EU institutions are among those participating in the Program. Differences exist between the EU standards and those that must be followed at the Fermilab site. A procedure for establishing safety equivalency has been created and is codified in FESHM Chapter 2110. This has been and continues to be actively used to establish safety equivalencies.

- An impedance grounding system to reduce electromagnetic interference (EMI) is planned for both detectors. This grounding system follows the same architecture as was used for MicroBooNE, so permitting of the SBN detector grounding systems is not expected to present significant hurdles. The "Gizmo" detector ground monitor that has been included in the plan has been proven to be a valuable means of ensuring the proper isolation of the detector ground.
- Reviews of CERN/INFN and Fermilab safety training programs have been performed, with reciprocity established for Aerial Lift, Confined Space, and Fall Protection.
- Risks involved in the physical movement and handling of large detector components has been identified as significant and requiring careful planning.
- Detector-proximate cryogenic components that are to arrive as in-kind contributions are now expected to be larger than initially anticipated.
- An incident with a Fermilab user occurred involving fall protection that did not comply with the regulations Fermilab must follow.

Comments

- The fall protection incident occurred despite the equivalency that was found between the CERN/INFN fall protection program and Fermilab's program. Safety culture and implementation should be given continued attention.
- An appropriately high level of attention is being given to material handling of detectors and detector support equipment and should continue.
- Access to and through the facility for first responders (e.g., fire fighters in turnout gear) must continue to be provided after experimental equipment is installed.
- Safe and ergonomic access to the detectors, detector support systems, and facility infrastructure will make safe work easier to perform and also minimize physical impediments to rapid execution of construction and servicing and maintenance during operation. Working space and access paths to and from electrical equipment have specific requirements in the National Electrical Code Article 110.26 that must be present for operation can be approved. The design of detector support systems and their physical arrangement must include adequate worker access as a primary consideration.

Recommendations

13. Continue to provide ES&H field inspections and support for assembly and service work on experimental equipment and systems.

14. Maintain clear access to and through the facility for first responders as experimental equipment is installed.

15. Locate detector components and subassemblies that may require servicing during experiment operation in readily accessible places with Code-required working space and access and connect with fittings and mountings that will ease and expedite service procedures.

16. Identify any more international standards to which equipment contributions from international partners will be constructed as early as possible so adequate time is provided to perform the safety equivalency reviews and implement the revisions to FESHM.

17. Submit the statement of equivalency for the saturable inductor impedance grounding system as soon as the documentation can be completed to expedite approval by the electrical AHJ.

18. Design large detector components to facilitate on-site assembly and installation, paying particular attention to lifting, rigging, working at heights, entrapment, and pinch points.

19. Locate permanent electrical receptacles to minimize the use of extension cords and power strips (other than rack-mounted power distribution modules) once detector installation is complete, and to facilitate installation and commissioning work as well as periodic servicing or maintenance.

3.3 Management

Subcommittee: Gina Rameika, Brenna Flaugher

Charge Questions:

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

  Yes. A strong management team has been assembled and is actively managing all elements of the Program. Over the past year, the creation of a MSP schedule, baselining it and using it to track cost and schedule is a very positive step. Creation of the risk register is also a sign of good progress.

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

  Probably. The human resources are likely to be available, but the current level of anticipated annual funding is not sufficient to complete the work on the desired schedule. A "possible plan" was presented that shifted SBND obligations into future years, delaying the start of SBND operations to 2021, but even this plan is short by >4M$ in FY19 and >3M$ in FY20. This analysis also does not include potential standing army costs, escalation etc. More planning and analysis is needed to determine a schedule that fits within anticipated funding.

- Are the remaining significant risks understood and adequately managed?

  In progress. Over the past few months the project has developed an initial detailed risk register and is in the process of updating it and assigning costs associated with all the risks.

SBN management plans to review it with the L2 managers quarterly and we encourage them to execute this plan.

- Has the program adequately investigated alternate solutions to address funding shortfalls relative to the baseline program scope?

  Not yet. Some cost savings opportunities for both detectors have been explored. Cost savings possibilities are in the range of $100k - $150k but would likely result in schedule delays. The cost impacts of such delays were not included in these estimates.

  Though some small savings solutions have been identified, even if these are realized the requested budget does not fit in the funding profile. The schedule for SBND is being pushed out due to lack of funds. There may be a point where significant descopes that get a reduced SBND on line sooner would be better than further delays.

- Is the boundary between construction/installation and operations well defined?

  No. As mentioned in the recommendations the SBN program would benefit from defining a clear end to construction/installation for each for the three subsystems (Infrastructure/Outfitting, ICARUS and SBND).

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

  Not yet, however, a starting point was presented in the Transition to Operations talk, but work needs to be done to review the list of tasks, estimate the resources needed, agree on the timeline for carrying out the tasks and then determine where those resources will come from.

Findings

- SBN is being managed as a program and not a DOE 413 project.
- The SBN Program has strong international collaborators who are making critical contributions to all aspects of the Program.
- The SBN Program, with its Liquid Argon detectors provides both a testbed for technology options under consideration for DUNE and is an example for organizing future international collaborations.

Comments

- Definition of clear end points to the construction phase (which includes detector installation) for each element of the Program (Infrastructure/Outfitting, ICARUS and SBND) would help manage SBN in many ways:
  - Definition of critical paths for each program element (Infrastructure/Outfitting, ICARUS and SBND) would be a useful tool for communication with collaborators.

- Costs associated with construction could be controlled separately from costs related to commissioning and operations.
- Development of an operations plan for each detector, as well as planning for operations resources could begin sooner.

- SBN management has incorporated all the costs they know of into the MSP schedule and has just started using EVMS to track progress. The schedule was baselined in May 2017. A change control process has started with 2 CRs implemented recently. Tracking history against the baseline has only been done since May 2017. This is great progress and several months more of tracking data will be invaluable to better understanding the remaining costs.

- The SBND schedule is very tight and budget pressures will tend to push more items onto the critical path, which in turn will make it less likely that the detector construction is completed on schedule.

- Communication with collaborators has been challenging due to many factors, including differing codes and documentation expectations. Written documentation of discussions and notes from meetings could help provide clarity for all parties.

- A risk management plan is in place and functional.

Recommendations

20. Include scheduled reviews (both major internal reviews and external reviews) as milestones in the schedule. Show durations associated with major testing programs in the schedule.

21. Define a milestone that represents a clear end to construction (which includes installation) for each program element (Infrastructure/Outfitting, ICARUS and SBND).

22. Define the critical paths for each program element and use them as management tools to communicate with collaborators and stakeholders.

23. Estimate liabilities and extra potential costs that are not included in existing MSP schedule. Compare these to the sum of the cost of the identified risks and consider performing a risk MC analysis.

24. Identify options for substantial reduction in costs - specifically address the question "where is the breakpoint for delaying SBND vs making significant changes in design to get on the air sooner?"

25. Make a complete estimate of the impacts of the expected funding profile. The "possible plan" is just shifting numbers from year to year, but does not include escalation, standing army etc.

26. Complete all necessary Work Package Agreements, particularly for the SBND cryostat.

27. Starting with the plan presented in the Transition to Operations talk, refine and identify the resources needed for ICARUS commissioning and operations.

28. Consider performing an analysis of the DOE-funded scope which presents the Program costs and labor in the units of CORE accounting so that the funding short-fall issues can be better explained to the international partners.

29. Hold another review in 6 months to examine cost and schedule performance against the baseline.

4.0 Appendices

A. Charge

B. Agenda

C. Review Committee Contact List and Writing Assignments

Appendix A

Charge

Director's Progress Review of SBN

November 1-2, 2017

Date:	**September 28, 2017**
To:	Mike Lindgren, Chief Project Officer
From:	Nigel Lockyer, Director
Re:	Director's Progress Review of the Short Baseline Neutrino Program

Message:

Please organize and conduct a Director's Review on November 1-2, 2017 to assess the progress of the Short Baseline Neutrino Program. This review should cover the following aspects of the program:

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

The focus of this review is progress to date versus plan and the forecast for completion of installation of ICARUS and SBND. Topics will include cost, schedule, management, ES&H, and technical readiness for the execution of the remainder of the SBN program. The review committee should respond to the following questions:

1. **Construction and Installation.** Is the overall progress on ICARUS installation, cryogenics and SBND construction consistent with the planned milestones? Are appropriate program driven technical reviews being planned, conducted and responded to? Are interfaces being adequately addressed?
2. **Cost and Schedule.** Are the cost and schedule basis of estimates for remaining DOE-funded work credible? Given the presented funding scenarios, is the SBN construction and installation schedule achievable? Are the schedules for the non-DOE deliverables compatible with the construction and installation schedule?
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, and installation of the SBN program and are these resources likely to be available when needed? Are the remaining significant risks understood and adequately managed? Has the program adequately investigated alternate solutions to address funding shortfalls relative to the baseline program scope? Is the boundary between construction/installation and operations 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 SBN
November 1-2, 2017

Wednesday, November 1, 2017

8:00 am	Full Committee Executive Session – **Comitium**	Gina Rameika
8:45 am	Welcome – **Hornet's Nest**	Nigel Lockyer
8:50 am	SBN Overview	Peter Wilson
9:25 am	SBND Overview and Schedule	Brian Rebel
10:00 am	ICARUS Detector Overview	Claudio Montanari
10:20 am	**Break**	
10:35 am	Infrastructure and ICARUS Install	Cat James
11:10 am	Transition to Operations	Steve Brice
11:25 am	ES&H	Angela Aparicio
11:45 am	**Lunch – 15th Floor Crossover**	

Breakout Session 1 – Management, Cost & Schedule, ES&H – Comitium

12:45 pm	Program Coordinator Details	Peter Wilson
1:25 pm	Response to Review Recommendations	Cat James
1:40 pm	Risk Management System	Mike Dinnon
2:30 pm	**Break Available – Outside of Comitium**	
2:45 pm	Cost and Schedule	Ken Domann

Breakout Session 2 – Electronics and DAQ – Snake Pit

12:45 pm	SBND TPC Electronics	Hucheng Chen
1:15 pm	SBND DAQ	Georgia Karagiorgi
1:30 pm	ICARUS DAQ	Angela Fava
2:30 pm	**Break Available – Outside of Comitium**	
2:45 pm	Open Q/A or join Breakout 3 in Hornet's Nest	

Breakout Session 3 – Detector – Hornet's Nest

12:45 pm	SBND TPC	Kostas Mavrokoridis
1:00 pm	SBND PMT	Richard Van de Water
1:15 pm	SBND CRT	Igor Kreslo
1:30 pm	ICARUS CRT	Anne Schukraft
2:30 pm	**Break Available – Hornet's Nest**	

Breakout Session 4 – Infrastructure – One East

12:45 pm	Cryogenics	Michael Geynisman
1:15 pm	Mech Outfitting	Steve Dixon
1:25 pm	Elec Outfitting	Linda Bagby
2:30 pm	**Break Available – Outside of Comitium & Hornet's Nest**	
2:45 pm	Join Breakout 3 in Hornet's Nest	

Combined Breakout Session 3 & 4 – Integration & Installation – Hornet's Nest

2:45 pm	ICARUS Installation	Fernanda Garcia
3:05 pm	SBND Cryostat	Marzio Nessi

3:25 pm	SBND Interfaces	Min Jeong Kim
3:35 pm	SBND Installation	Juan Estrada
4:30 pm	Full Committee Executive Session – **Comitium**	Gina Rameika
6:00 pm	Adjourn	

Thursday, November 2, 2017

8:00 am	Full Committee Working Session – **Comitium**	Committee
11:00 am	Full Committee Executive Session/Dry Run and Working Lunch	Committee
1:00 pm	Closeout – **Hornet's Nest**	
2:00 pm	Adjourn	

Appendix C

Review Committee Contact List and Writing Assignments

Director's Progress Review of SBN

November 1-2, 2017

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