U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

Review Closeout

for the

Long Baseline Neutrino Experiment (LBNE) Project

at

Fermi National Accelerator Laboratory

November 1, 2012

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Review Committee Chair
Office of Science, U.S. Department of Energy
http://www.science.doe.gov/opa/

Review Committee Participants

Daniel R. Lehman, Chairman

SC1 Beamline

* Tom Roser, BNL
Kevin Jones, ORNL
Phil Pile, BNL

SC2 Detectors

* Bill Wisniewski, SLAC
Richard Loveless, U of Wisconsin
David Nygren, LBNL

SC3 Conventional

* Marty Fallier, BNL
Brad Bull, MSU/FRIB
Bob Law, SLAC

SC4 Environment, Safety and Health

* Ian Evans, SLAC
Frank Kornegay

SC5 Cost and Schedule

* Barbara Thibadeau, ORNL/SNS
Rick Blaisdell, DOE/APM
Kin Chao, DOE/SC
Kurt Fisher, DOE/SC
Brian Huizenga, DOE/APM

SC6 Management

* Aesook Byon, BNL
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Observers

Jim Siegrist, DOE/SC
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John Kogut, DOE/SC
Alan Stone, DOE/SC
Pepin Carolan, DOE/FSO
Steve Webster, DOE/FSO
Mike Weis, DOE/FSO
Jerry Kao, DOE/ASO
Hemant Patel, DOE/BSO
Glenn Kubiak, LBNL

LEGEND

SC Subcommittee
* Chairperson
[ ] Part-time Subcommittee Member

COUNT: 22 (excluding observers)

Charge Questions

1. Does the conceptual design provide increased research capabilities envisioned in the mission need? Does the conceptual design satisfy the performance requirements recently recommended by the LBNE reconfiguration steering committee?

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration?

3. Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2?

4. Are ES&H aspects being properly addressed and are future plans sufficient given the project's current stage of development?

5. Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval?

2.1 Beamline

Roser* and Pile, BNL; Jones, ORNL/SC1

1. Does the conceptual design provide increased research capabilities envisioned in the mission need? Does the conceptual design satisfy the performance requirements recently recommended by the LBNE reconfiguration steering committee? **YES**

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? **YES**

3. Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2? **YES**

5. Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval? **YES**

- **Findings**
  - Scope of primary beam system covers high intensity beam transport of 4.9e13, 60 – 120 GeV protons per pulse from MI-10 extraction point of the Main Injector to the target station. Beam losses should be less than a few ppm.
  - Total beam power is 700 kW with capability for upgrade to 2.3 MW with only minor additional expense
  - Above grade beam transport over a 58 foot hill to achieve 101 mrad targeting angle towards far detector
  - The technical scope of the neutrino beam is comprehensive and complete.
  - Several of the systems for the neutrino beam will be designed to accommodate an upgrade from 700 kW to 2.3 MW beam power.
  - The decay pipe cooling baseline is forced air through the annulus and bore of the pipe but other options are being considered.

2.1 Beamline

Roser* and Pile, BNL; Jones, ORNL/SC1

- **Findings**
  - The neutrino beamline project has undergone several alternate analysis studies; the latest value engineering iteration, including tunability of the neutrino beam, closely follows NUMI/NOVA designs and resulted in a total savings of about $96M but with a ~25% decrease in flux of the neutrino beam at low energy.
  - Alignment tolerances are taken from NUMI experience but will be based on physics requirements once the studies are complete early next year.
  - Spares are off-project but will be purchased with project funds with the understanding that FNAL will reimburse the project.
  - An Interface Document Matrix Chart and associated documents and a draft Installation Plan address complex installation roles and interfaces.
  - System Integration plans are established and the scope of support functions such as controls and alignment is well defined.

2.1 Beamline

Roser* and Pile, BNL; Jones, ORNL/SC1

- **Comments**
  - Excellent proton beam strong focusing optics to minimize beam size
  - Similar to the NuMI beam line the transport channel contains 100% of available MI aperture at transition energy even at 60 GeV - since little emittance growth occurs after transition this should ensure very low beam losses in the LBNE beam line.
  - There is small residual beam loss in the NuMI beam line that is not understood. The cause of this beam loss should be understood and the corresponding loss for the LBNE beam line should be estimated, in particular for the 60 GeV, 2 MW mode.
  - The larger aperture of the LBNE beam line may improve beam permit system and loss control and is based on successful experience with NuMI.
  - The cost of magnets and magnet installation are based on solid experience from NuMI and past fabrication documentation.
  - The beamline project is developed with a high level of detail beyond what is expected at the CD-1 level. The team should be commended.

2.1 Beamline

Roser* and Pile, BNL; Jones, ORNL/SC1

- **Comments**
  - The decay pipe, once installed, will constrain the neutrino beam energy spectrum for the expected life of the facility and analysis for the CD-1 design choice emphasized cost reduction. The project should continue to work closely with the physics working group to ensure that the chosen decay pipe dimensions are indeed optimum for the experiments planned and possible future experiments. The added cost should be weighed against the high cost to operate the facility.
  - Lessons learned from NuMI/NOVA, and identified improvements, have been applied across the board in the development of scope, schedule and cost for the beamline task of LBNE.
  - Given that installation activities start in 2020, a staffing plan to address succession planning for key staff may be useful

2.1 Beamline

Roser* and Pile, BNL; Jones, ORNL/SC1

- **Recommendations**
  - Complete analysis, in collaboration with the physics working group, to ensure that the chosen decay pipe dimensions are optimum for planned and future experiments before CD-2.
  - Approve CD-1 for the beamline.

2.2 Detectors

R. Loveless, UWisc; D.Nygren, LBNL; Wisniewski, SLAC*

1. Does the conceptual design provide increased research capabilities envisioned in the mission need? Does the conceptual design satisfy the performance requirements recently recommended by the LBNE reconfiguration steering committee? **Yes, the conceptual design satisfies the requirements of Phase 1.**

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? **Yes.**

3. Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2? **Yes.**

5. Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval. **Yes.**

- **Findings & Comments**

  - The Detector Team is commended for the progress that has been made in planning the reconfigured project. The proposed detector will record neutrino-induced events from FNAL with good efficiency, and without serious degradation from cosmic rays entering the active volume. Significant effort has been successfully invested in quick move from the detailed plans for an underground LAr Far Detector (FD) to plans for a smaller near surface FD. The Near Detector Complex (NDC) has undergone extensive scope reduction, and remains more of a work in progress.

  - The Committee observes that an extensive value engineering effort has been carried out, backed by a change control system. The effort has paid off. One opportunity for optimization is consideration of replacing the two FD cryostats with a single cryostat. For the same volume of LAr, this is likely to lead to cost savings accompanied by increased fiducial volume. Alternatively, cost savings might be realized if the fiducial volume is kept to 10kt. Use of a single large cryostat plays better to industrial expertise as well.

- The cryogenics and cryostat design is quite mature for CD-1 and gives confidence that the execution of the plan will be successful. The use of an experienced consulting firm, along with FNAL cryogenics experts, provides a solid basis for the estimates, which are backed by substantial contingency.

- There is uncertainty in the Photon Detector sensitivity. The Committee encourages vigorous R&D to optimize this sensitivity and to determine if additional detectors should be included in the APAs.

- Selection of a robust wavelength shifter (WLS) to coat the lightguide plastic that carries scintillation signals to the SiPMs can affect anode plane construction and APA installation, because additional care may be needed to forestall its environmental degradation. It is important that downstream construction practicalities weigh into the R&D for WLS development and selection.

- The TPC effort is proceeding well and is narrowing down on a final design. The plan to produce modules at multiple sites is likely to prove unrealizable. The winding machine that is likely to be needed to produce the many required APA modules will be complex enough that single site production is required.

- The FD DAQ subsystem relies on uncosted physicist labor for 65% of its labor resources. It is important to get right the balance of software professionals and physicists to best execute the project. The committee suggests that the subsystem add software professionals to its plan and budget.

- Reliance on the NOvA DAQ design as a model offers some opportunity for reliability where applicable. The Committee feels that FD DAQ should not give up too readily on supernova neutrinos, where the cost increase may be limited to increased data buffering.

– In the reconfiguration process, the Near Detector Complex has been reduced in scope to the Beam Line Monitoring (BLM) system. The BLM does not provide direct measurements of neutrino flux, but instead samples the muon flux emerging from the beam stop using three quite distinct techniques: ion chambers, variable-threshold Cherenkov detectors, and stopping muon detectors. The determination of the emergent neutrino spectrum and flux is thus indirect, and must rely on the anti-correlation of muon and neutrino energies, and a chain of external measurements to complement the BLM. Substantial risk appears to exist in this circumstance: after extensive operation acquiring data, new LBNE results, perhaps unexpected and intrinsically of high significance, may be confounded by ambiguity not resolvable by the BLM and external information. The quantifiable aspect of this risk is the costly choice to deploy, or not, a Near Detector with capability to measure the neutrino flux. No other risk approaches this one in significance.

- Development of the LArSoft package is making good progress. As the decision on Geotech surveys is due in four months, LArSoft will not be able to comment on possible background advantages of a hillside FD site versus a flat field site. The Committee sees LArSoft as an important tool that needs prompt development. More manpower is needed here. The Committee also suggests that it would be prudent for Management to obtain Geotech Surveys of both sites in the absence of the availability of this physics tool.

- The 35t LAr test cryostat effort has yielded insights into cryostat construction. The FD team intends to test many detector elements in this cryostat, with work to be completed a year before CD-2.

- The fraction of cost dedicated to Management varies widely among the detector subsystems. The team should review and verify that this wide distribution meets needs.

- **Recommendations**

1. Conduct a value engineering study of the advantages/disadvantages of a one cryostat versus two cryostat FD design in preparation for CD-2

2. Increase manpower devoted to development of the simulations by April 2013 so that this tool will provide more timely input to project design decisions.

3. Focus effort on achieving a clearly defendable determination of the adequacy of the BLM in lieu of a Near Detector (with BLM) for Phase 1 measurements in preparation for CD-2.

4. Recommend CD-1 approval.

3. Conventional Facilities

M. Fallier-BNL, B. Bull-MSU, R. Law-SLAC /SC3

1. Does the conceptual design provide increased research capabilities envisioned in the mission need? Does the conceptual design satisfy the performance requirements recently recommended by the LBNE reconfiguration steering committee?

   Yes

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration?

   Yes, however upper range escalation rates may be low. Schedule durations appear adequate with opportunities to shorten durations if the funding profile allows

3. Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2?

   Yes, but the project office should pay careful attention to the matrixed line management relationships as the project progresses due to high number of matrixed staff

5. Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval?

   Yes

- **Comments**
  - The LBNE CF Staff is to be commended for the thorough revamping of project scope and analysis of alternatives, particularly for Far site construction
  - Current level of matrixed staffing is high and more permanent staffing should be secured as the project matures to assure ownership of major WBS elements
  - Current scope appears appropriate for the scientific goals however there is no scope contingency

- **Comments Cont'd**
  - The cost estimate is commensurate with the scope, risk based contingency is appropriate for this stage of the project however upper range escalation may be optimistic and should be reevaluated
  - Current schedule is funding constrained and can be accelerated if funding allows, however good use of lag time is being made to enhance embankment settlement
  - Construction plans for the Near Site have inherent vibration concerns which will require additional analysis
  - The geotechnical investigation, and drilled pier design for the near site should be pursued as soon as possible to confirm this risk reduction opportunity prior to CD-2

- **Recommendations**
  - The proposed long lead procurements should be pursued by the project to mitigate cost and schedule risk
  - The decision on where to locate the Far Site detector should be made in time to confirm requirements and incorporate in CF scope for the CD-2 baseline
  - Ready for CD-1

4. Are ES&H aspects being properly addressed and are future plans sufficient given the project's current stage of development? Yes

5. Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval? Yes

Comments

- To support an Environmental Assessment (EA) and dismiss confusion of environmental issues associated with earlier projects, communications with interested parties will be important to acceptance of the proposed NEPA compliance strategy. Equally a well defined Scope of Work for preparation of the EA will help better define costs.
- Processes established to analyze routine operations and mis-steering events for radiation effects appear to be sufficient to ensure minimal radiological impacts to workers and offsite from the Project. Experience with tritium production at NuMI is being factored into the LBNE design and operation plans.

Comments

- ES&H staff assigned to the Project are experienced and competent. Institutional ES&H support has been effectively used, and the Laboratory has committed to provide locations for the long-term storage of activated components from LBNE.
- The responsibility for ES&H programs and oversight at the Far Detector Conventional Facility has been defined, and should properly support the Project. Transitioning to Fermi control (and 10 CFR 851 applicability) at the Far Detector Hall for installation activities and operation appears to be appropriate and efficient.

Recommendations

- Proceed to CD-1
- Document the Project's tritium mitigation strategy in a FermiLab report prior to the CD-2 Review
- Define and document Lab. commitments to project. (i.e. Radioactive Storage Area, Steel Shielding, NuMI equipment, Cooling Pond) prior to the CD-2 Review

2. **Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration?**

   Generally yes, although the cost range should be reviewed to ensure that the uncertainties associated with such a long duration project have been incorporated.

3. **Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2?**

   Yes. The current staffing plan supports the development of a credible cost and schedule baseline for CD-2.

5. **Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval?**

   Yes, once the recommendations have been addressed.

Findings

- With respect to the cost and schedule related documentation, the project has developed drafts of a Risk Management Plan, a Preliminary Project Execution Plan and a Project Management Plan.
- The project has presented a TPC of $867.4M (which includes $235.5M (40% of contingency on work to go) and a cost range of $687M-945M. The lower value of the range has a 5% confidence level, the upper value a 95% confidence level.
- The cost estimate is very detailed and supported by 120 Basis of Estimate (BOE) backup files. The project uses different escalation rates for FNAL and BNL labor, LANL labor, FNAL and BNL M&S and LANL M&S resources. Conventional facilities activities use another set of escalation rates based on industry forecasts. The basis of estimate and estimate contingency values are applied consistently across the project.
- LBNE Costs breakdown as 66% Materials and Services (M&S), 33% labor.
- A bulk of the estimate (46.6%) is based on engineering experience with similar items
- The project's obligation profile includes on 20% contingency during FY13-FY16 and ramps up to 38% per year starting in FY17.
- The project has not received preferential indirect rates at any of the participating institutions.

Findings (continued)

- The project TPC includes three different types of contingency (estimate uncertainty contingency, risk uncertainty contingency and a top down contingency amount developed by the project manager).
- The project has not included any cost contingency to cover the two years of schedule float.
- The project is planning for a CD-3a for initial CF work (approximately $20M) in Q3 FY15 and CD-2 in Q3 FY16. The proposed project duration includes 2 years of schedule float.
- The project has identified scope contingency items, as well as appropriate decision dates.
- The project has identified 2 separate critical paths, one at the near site and one at the far site.
- The project is funding limited.
- The project schedule includes labor hours for the uncosted scientific labor that will be required by the project.

Comments

- **The project has an impressive amount of material supporting the cost and schedule range and should be commended for the level of detail available at this point.**

- **The estimate is well supported & drill-downs with randomly selected CAMs show that the CAMs have carefully thought out their estimates and schedules and understand the rationale applied to the BOE and estimate uncertainty values. In at least one case (130.05.02.05), there is an inconsistency between the estimate uncertainty and the BOE. One would assume that a low risk BOE (e.g., one based on designs/sketches) would not carry a high estimate uncertainty). Once the data is aggregated, the project should do a quick review to ensure that these two parameters are consistent with each other, especially on the larger dollar value elements.**

- **The lower value of the cost range should have more than a 5% confidence level. It needs to be an amount that the project believes that they could reasonably complete the project with.**

Comments (continued)

- There is overlap of a few sections of the PPEP, RMP and PMP.
- The objective KPP "Additional detector mass and/or underground siting facility facilitated by non-DOE in-kind contributions" sounds like off-project scope.
- The change control threshold table is not clear with regard to changes <$500K and the use of management reserve.
- The project documentation should include EVMS variance thresholds and guidance on the process and periodicity with which estimates will be updated.
- The LANL labor escalation rates appear high, especially in comparison to those used by the other laboratories.
- Even though the project is not charged for the direct labor hours for the uncosted labor, there may be additional "overhead" charges associated with arranging visits, access to the lab, training requirements etc. that may not have been captured in the cost baseline.

Recommendations

Prior to CD-1:

- Revisit the lower bound of the cost range to a value that has more than 5% confidence and is a value that the project could be completed within.
- Revisit the upper bound of the cost range to account for uncertainties resulting from the project's long duration
- Clean up and finalize the draft documents

Prior to CD-2

- Revisit the LANL escalation rates.
- Re-evaluate escalation model (including consideration of a possible rebound in the civil construction industry)
- Finalize and document the indirect rates that will be used on the project for its duration.

PROJECT STATUS (September 30, 2012--Pre-Baseline)		
Project Type	Line Item	
CD-0		Actual:01/08/10
CD-1	Planned: 01/2013	Actual:
CD-3a	Planned: 04/2015	
CD-2	Planned: 04/2016	Actual:
CD-3	Planned: 04/2017	Actual:
CD-4	Planned: 04/2025	Actual:
TPC Percent Complete	Planned:	Actual: ~7.1 %
TPC Cost to Date	$44.8M	
TPC Committed to Date	$44.8M	
TPC	$867.4M	
TEC	$810.6M	
Contingency (w/Mgmt Reserve)	$235.5M	40.1% to go
Contingency Schedule on CD-4	24 Months	19%
CPI Cumulative	N/A	
SPI Cumulative	N/A	

6. Management

Byon BNL, Glasmacher MSU, Landini DOE, Lutha DOE, Meador DOE

3. Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2?

   Project has a lean, effective management team and adequate staffing in place for this phase of the project. However, the project management team needs to be strengthened and the staffing plan will require careful re-evaluation over next couple of years.

5. Have all prerequisite requirements for CD-1 approval been satisfied? Is the project ready for CD-1 approval?

   Project is ready for CD-1 approval. Prerequisite documents to support CD-1 were developed but will need to be finalized with the final cost range.

6. Management

Byon BNL, Glasmacher MSU, Landini DOE, Lutha DOE, Meador DOE

- **Findings & Comments**

– The project team and the laboratory should be complemented for successfully restructuring the project to initiate the first phase of the neutrino physics facility.
– Proposed scope of the project will initiate construction of a world-class facility for the high-intensity neutrino physics program and enable continuing expansion of the facility's capabilities in the future.
– Technical progress is advanced and mature enough to establish the alternative selection and cost and schedule ranges.
– The size of management team is adequate and effective at this phase of project. Project management and lab management are aware that the project management team needs to be strengthened over the next couple of years.
– No significant technical issues were identified but questions were raised concerning the appropriate cost range and schedule estimate due to the heavily back-loaded funding profile. Some clarifications and refinements are needed in order to get agreement on the appropriate cost range for CD-1 approval.
– Prerequisite documents to support CD-1 are developed but will need to be finalized with the final cost range.

6. Management

Byon BNL, Glasmacher MSU, Landini DOE, Lutha DOE, Meador DOE

- **Findings & Comments**

– The proposed plan has ~0.25 FTE /person (=# of FTE planned/# head count) in FY13 for the beamline and detector activities. Identifying and securing committed matrixed labor from Fermilab will be one of the major challenges for meeting the project cost and schedule goals.

– The project proposes to perform construction management (CM) functions in-house, but augmented with outside CM experts as needed. CM is a critical function that needs to be carefully considered as the project begins preliminary design.

– Project management processes, although mostly well documented and being implemented could benefit from continuing adjustments based on the refinements identified during implementation and execution.

– The project has plans to implement peer advisory committees with practitioners from other large DOE-SC construction projects.

– Project should consider accelerating CD-2 request date in order to create more built-in schedule float.

6. Management

Byon BNL, Glasmacher MSU, Landini DOE, Lutha DOE, Meador DOE

- **Findings & Comments (continued)**

– In order to be ready for CD-2, the project should:
  – Reassess staffing plan
  – Provide updated obligation profile based on accelerated CD-2 target date and its impacts to the project
  – Finalize SDSTA lease agreement
  – Complete the NEPA documentation
  – Implement regular peer advisory committees to facilitate lessons learned from recent large DOE-SC construction projects
  – Complete Decision Matrix items required by DOE O 413.3B

6. Management

Byon BNL, Glasmacher MSU, Landini DOE, Lutha DOE, Meador DOE

- **Recommendations**
  - Re-evaluate proposed cost range.
  - Proceed with CD-1 Approval after finalizing PPEP and appropriate CD-1 prerequisite documentation.
  - Schedule the next DOE/SC progress review of the LBNE project in May/June 2013 time frame.