
# Closeout Presentation

# Director's CD-1 Review of LBNE

## September 25-27, 2012

This page intentionally left blank

# Table of Contents

This page intentionally left blank

## Executive Summary

This Fermilab Director's review of the Long-Baseline Neutrino Experiment (LBNE) Project assessed the project meets the Critical Decision 1 (CD-1) "Approve Alternative Selection & Cost Range" requirements as specified in DOE O 413.3B. An additional goal of the review was to prepare the LBNE project for a planned DOE Independent Project Review/Independent Cost Review (IPR/ICR) scheduled for October 30 – November 1, 2012.

The review committee is confident that the LBNE Project will be ready for a successful DOE CD-1 review in one month. The recent reconfiguration of the project scope was well executed yielding a revised scope that satisfies the performance requirements recommended by the LBNE reconfiguration steering committee. The reconfigured LBNE project provides the increased research capabilities envisioned in the CD-0 mission need statement.

The team understands the requirements and documents needed for CD-1. There is good progress preparing the documentation and most documents are in place or will be completed prior to the DOE CD-1 review.

The current DOE funding profile guidance for the LBNE project is back-end loaded and not consistent with a technically driven schedule. The current schedule proposed is simply far longer than necessary. While this is largely driven by the assumed funding profile there are also key assumptions on review cycles and timing of procurements that contribute to the overall schedule duration. The LBNE project management should develop an aggressive approach to the schedule and exploit all flexibilities available to shorten the overall schedule, including an earlier start of fabrication and construction. The project leadership should work with DOE to define a strategy for the DOE Critical Decision process that supports the earliest possible completion date. The project leadership should also work with DOE to try to improve the funding profile to advance key procurements and activities.

The base estimate of $624.9M is judged to be reasonable. A contingency allocation of 40% is adequate for this stage of the project.

The LBNE Project is a strong team and the collaboration membership has grown.

The conceptual design should satisfy the performance requirements pending affirmation by the forthcoming technical review addressing Far Detector performance operating on the surface; and the demonstration that the Near Detector complex and associated NuMI validation measurements can meet the requirements of the LBNE research program. This information should be included in the LBNE Conceptual Design Report.

The committee provides a number of detailed comments and recommendations in the report. Some recommendations should be addressed prior to the DOE CD-1 review and others can be addressed after the review.

# 1.0 Introduction

A Director's CD-1 Review of the Long-Baseline Neutrino Experiment (LBNE) Project was held on September 25-27, 2012. The focus of this review was to assess if the project meets the Critical Decision 1 (CD-1) "Approve Alternative Selection & Cost Range" CD-1 requirements as specified in DOE O 413.3B. Additionally, the committee reviewed the changes to the project's design since the Director's Independent Conceptual Design and CD-1 Readiness Review conducted on March 26-30, 2012. The charge included a list of topics and specific questions to be addressed as part of the review. The assessment of the Review Committee is documented in the body of this closeout presentation.

Each section in this closeout presentation is generally organized by Findings, Comments and Recommendations. Findings are statements of fact that summarize noteworthy information presented during the review. The Comments are judgment statements about the facts presented during the review and are based on reviewers' experience and expertise. The comments are to be evaluated by the project team and actions taken as deemed appropriate. Recommendations are statements of actions that should be addressed by the project team. The remainder of this presentation has the answers to the review charge questions.

The LBNE Project is to develop a response to the review recommendations and present it to the Laboratory Management and regularly report on the progress during the LBNE Working Group Meetings (WGM). A response to the recommendation(s) is expected and the actions taken will be tracked to closure. The statuses of these recommendations are to me made available during future reviews.

# 2.0 Detector

## 2.1 Cryogenics and Cryostat

**Primary Writers: Joel Fuerst**

**Contributor: Jay Theilacker**

### Findings

- The LBNE project proposes to build and operate a 10 kton fiducial mass liquid argon (LAr) TPC at surface level in Lead, SD. The detector would consist of two membrane-type cryostats containing a total of 18.8kton liquid argon at 1.13 bar abs pressure with LAr and $LN_2$ cryogenic delivery, purification and refrigeration services located adjacent to the detector hall.

- A liquid nitrogen refrigeration system is provided to re-condense boil-off argon vapor. It consists of three 55 kW capacity units. Two units will be used during cool-down and fill of a cryostat. One unit is required for steady state operation of a single cryostat. This will result in one spare unit once both cryostats are in steady state operational condition.

- Successful purification of a non-evacuable vessel has been accomplished in LAPD. Further operation of LAPD will test photon detector components.

- A preliminary ODH analysis was prepared for the 33 kton detector at the 4,850 foot level suggesting an ODH classification of 1 based on a fatality rate of $1.5 \times 10^{-7}$ per hour.

- The main pressure relief valve will also address the case of under-pressure in the cryostat, by allowing air-inlet into the cryostat to assure that the pressure is not dropping below acceptable limits.

- Changes which have taken place since the March 2012 Director's review are:

    - The cryostat size has been reduced
    - Cryostat insulation has been reduced from 1.0 m to 0.8 m.
    - The vertical pipe runs have been eliminated now that the cryogenic system and cryostats are on the same level.
    - Cryogenic system piping is being re-sized due to length and vertical run reductions.
    - The number of submerged LAr pumps has been reduced from 4 to 2 per cryostat.
    - The number of filter vessels has been reduced.
    - All filtering has been moved to a separate surface building.
    - Capacity of the three $LN_2$ plants was reduced to 55 kW each.

- Added a second $LN_2$ dewar to increase the backup time from 29 hours to 40 hours.

- The basis of estimate for the cryostat and cryogenics is based on a detailed report prepared by an outside engineering firm for a larger detector size at the 800' level. The estimate was scaled to 10 kton at surface level by project personnel. The M&S and labor estimates assume that an outside engineering firm will also be used to prepare the preliminary and final designs.

- The Cryogenic and Cryostat labor shows 1.25 FTE for a five year period (FY14-18) between two peaks that represented prototyping and project execution. The majority of the 1.25 FTE was listed as administrative.

- The LAr Cryogenics & Cryostat cost estimate was presented as:

| | Labor | | M & S | | To-Go Contingency | | |
|---|---|---|---|---|---|---|---|
| | Base Cost | Contingency | Base Cost | Contingency | $ | % | TPC |
| 130.05.02 LAr Cryogenics & Cryostat | 10,792 | 2,418 | 99,783 | 36,167 | 38,585 | 37% | 149,161 |

| WBS | Element | Base Cost (Labor + M&S) | Cost Fraction |
|---|---|---|---|
| 130.05.02.05.01 | Conceptual Design | $1,883 k | 2% |
| 130.05.02.05.02 | Preliminary Design | $2,717 k | 3% |
| 130.05.02.05.03 | 35 t Prototype | $3,465 k | 3% |
| 130.05.02.05.04 | Final Design | $4,694 k | 4% |
| 130.05.02.05.05 | Construction | $65,934 k | 60% |
| 130.05.02.05.06 | Fluids Procurement | $25,764 k | 23% |
| 130.05.02.05.07 | Checkout | $387 k | 0% |
| 130.05.02.05.08 | Management | $5,731 k | 5% |

- The prototyping schedule is as follows:
    - 35 ton Phase I: MAR-AUG 2013
    - LAPD Phase II: mid-CY 2013
    - 35 ton Phase II: CY 2014 – CY2015

- There are only two vendors available world-wide for the design of membrane vessels. Fermilab continues to pursue an agreement with one of the vendors related to intellectual property.

- The cool down rate of the detector is limited by the stresses in the TPC, not in the membrane vessel. Thermal modeling has been made to calculate the temperature differences in the TPC in order to help predict acceptable cool down rate. It is planned to verify the thermal model during Phase II operation of the 35 ton vessel. A scaled TPC will be adequately instrumented for this purpose.

- Cryostat construction is scheduled for FY2020 with installation/test/fill in FY2021+

- Fabrication of a single 5 kton cryostat costs $12.576M.

- The LAr FD consists of 18.8 kTon total mass, 13.5 kTon active mass, 10 kTon fiducial mass.

- A deputy L3 manager is planned to be added to the project.

- Purification via piston purge has been verified in LAPD and will be confirmed in the 35 Ton Phase I test.

- The temperature gradient in an "empty but cold" cryostat has been modeled. There may be a need to add flow jets to enhance mixing to reduce stratification.

- The LAr cryostats will be designed & fabricated according to the relevant membrane vessel codes as well as American Concrete Institute (ACI) codes.

- The project has investigated the long term availability of LAr and determined that the required quantity will be available on the required timescale.

- Eight LAr tankers/day would be required for ~ 45 days to fill one LAr cryostat. The planned on-site storage is capable of handling the inventory contained in three LAr tankers.

## Comments

- The cryogenic team has been proactively engaged with both membrane vessel manufacturers in the needs of the project. This effort is to be commended.

- An engineering firm was incorporated in the conceptual design, resulting in a strong design, cost and schedule report. As a result, the BOE for this high cost element is very credible. The committee was impressed with the level of detail.

- There appeared to be an inconsistency in project schedules which may be the difference between showing obligation schedule versus task schedule.

- The intellectual property barrier with one membrane vessel manufacturer represents a risk toward achieving a competitive bid. There is still work to be done between the FNAL and GTT legal offices pertaining to intellectual property before they can be considered a viable cryostat source.

- The thermal cycle rate must not overstress the cryostats or the TPC components. The team should clearly identify the limiting component(s) which is believed to be the TPC. Consequently the cryogenics system design needs to be provided with a maximum cool down rate of TPC system components.

- The project is being very careful to qualify all materials for compatibility with ultrapure LAr. The project should make sure the submersible LAr pumps or any other commercial equipment meet the specification.

- The project should investigate what pressure safety rules are in place at the Sanford Laboratory. In addition, the project should ensure that the system follows the requirements of 10CFR851.

- Insulation thickness has been reduced to the membrane vessel manufacturer's standard thickness. This helps reduce uncertainty and thereby costs with respect to possible mechanical stresses of a non-standard design.

- The allotment of labor for contract oversight appears to be low.

- The current plan is to have a single contract for cryogenic systems and cryostat construction. The scope of this work may exceed the area of expertise of a single vendor. It may be cost effective to divide the work into multiple contracts. For instance, the cryogenic system lends itself to modular fabrication which can be performed at manufacturer's facilities and later combined on-site. It is recognized that multiple contracts will require additional project oversight.

- There will likely be LAr delivery complications due to the limited available on-site storage.

## Recommendations

1. Consider writing a membrane cryostat design chapter for the FESHM prior to CD-2/3a.

2. Evaluate dividing the cryogenic system and cryostat contract to better match the expertise of available vendors before CD-2.

3. Add quantitative technical detail to the “Cryogenics and Cryostat” technical requirements before CD-2.

4. Reassess the level of labor required to oversee cryostat design contracts before CD-2.

## 2.2 TPC/DAQ/Electronics

**Primary Writers: Bill Christie**

**Contributor: Bob Tschirhart, Mike Tuts**

### Findings

- The drift distance for the Time projection Chamber has been reduced to 2.3 m. This gives a maximum drift time, from Cathode to Anodes of 1.4 ms.
- The costed Scientific labor on the Far Detector system is 39 FTE. The un-costed Scientific Labor if 38.2 FTE.
- The contingency for the Near Detector is currently 151%.
- The timing accuracy specification for the photon detection system is ~ 1 us.
- The reference design for the photon detection system is to use flat light guides, custom fit onto multi-anode photo multiplier tubes.
- The use of alternative light guide designs, with SiPM readout is under consideration.
- The photon detection system schedule is tied to the APA assembly schedule.
- The cost for one of the 1200 photon detector ladder assemblies, including electronics, is on the order of 7 k$.
- A small APA prototype has been built and tested for thermal stresses. A larger, but still not full scale APA, is currently under construction. These represent two different APA designs.
- The positive ion drift time from the APA to the CPA is on the order of 5 minutes. This leads to some space charge related distortions in the drifting electrons in the TPC.
- The estimate for the largest distortion in the drift direction of the TPC due to the space charge build up is ~ 6 mm.
- The manpower plot (FTE per year and integrated vs year) for the TPC will be updated prior to the CD1 review.
- The total cold electronics count for the TPC is 307,200.
- There will be 20 “Mother Boards” per APA.
- The Front End ASIC design is complete.

- The ADC ASIC design is in progress.
- There are some inconsistencies in the numbers presented for the electronics system related to the drift distance.
- The manpower plot (FTE per year and integrated vs year) for the TPC electronics will be updated prior to the CD1 review.
- The baseline plan/cost is to design an ASIC for the zero suppression logic.
- The time stamp accuracy specification for the time stamp that the DAQ system will provide is 1.4 ms.
- The timescale for the 35 t prototype effort completion is < 2016.
- Phase II of the 35 t effort is a small scale test of all systems needed for a working TPC.
- The Phase I effort is primarily focused on demonstrating the membrane and cryogenics technologies.
- The Phase I duration is from March to August 2013.
- The FE ASIC and ADC ASIC will be incorporated into one new "Hybrid" ASIC.
- The project is retaining a DAQ architecture with streaming that was appropriate for the underground implementation.
- The cost of DAQ components does not account for likely cost reductions due to Moore's law.
- The development of monitoring software is off project.
- The funding model for the SURF liaisons up through and including beneficial occupancy was not presented.
- There will be a cold test of the electronics chain in 2013.
- Phase II will enable development of reconstruction and analysis software that is not on project.
- There will be a test of photon detector designs in the LAPD in late 2013.
- To reduce risks, a calibration system for the LAr TPC will be added into the project. That cost is not currently included in the cost estimate.
- A preliminary cost estimate for a Laser calibration system is the order of 1 M$.

- A forthcoming review by a panel of experts will review the impact of the cosmic ray background and space charge distortions on the LBNE research program.

- An analysis of the required performance of the Near Detector (ND) complex and required associated NUMI measurements is not included in the CDR.

- The largest risk for the ND project is the lack of a neutrino measuring detector in the ND.

- There is insufficient scientific manpower available to the ND effort prior to CD2.

- There was no task/effort shown in the high level schedule for the ND between the Conceptual and Preliminary design stages.

- The committee did not hear anything about how property management will be dealt with by the project.

## Comments

- There is much in the Detector area that has progressed well beyond a CD-1 level, and the team should be commended.

- The management team is strong and capable of managing the project.

- The overview Cost & Schedule presentation demonstrated an impressive level of detailed information incorporated into the Project Management system.

- The un-costed scientific effort can be confusing to a reviewer. The project correctly captures the effort for that un-costed manpower, and correctly leaves out the cost. However, if possible, it would be helpful in the manpower profiles shown in the presentations if the costed and un-costed scientific effort could be differentiated.

- The DAQ system, in particular, relies heavily on un-costed scientific manpower (postdocs, students, etc). It would be helpful to a reviewer to understand the nature of all manpower in this area and what type it is – i.e. how many computer professionals, postdocs, students etc. are planned.

- In some experiments (admittedly rare these days), there can be non-scientific technical effort contributed (un-costed, off-project) by universities. It was not clear whether any manpower of this type is captured in the project manpower tables.

- It may be prudent to consider whether there may be any export control issues associated with the custom designed electronics.

- We are aware that there is reliance on MicroBooNE for analysis and algorithm development. To understand the risk associated with this manpower it would be helpful to understand the size of these uncosted and unaffiliated efforts.

## Recommendations

5. Insert a task or tasks in the interval between the Conceptual Design and the Preliminary Design efforts, as costs are apparently incurred for the Near Detector project during this time period, but no tasks were shown in the high level schedule. This must be done prior to the CD1 review.

6. Create a milestone by which the TPC group must provide the maximum cool down rate specification to the Cryogenics group prior to CD2.

7. Create a milestone indicating when a final Anode Plane Assembly design will be selected prior to CD2.

8. Include an analysis demonstrating the plausibility that the Near Detector Complex (reference design) and the associated NuMI calibration and validation measurements can deliver the required performance to the Conceptual Design Report prior to CD1.

9. Decide whether a neutrino detector is necessary at the Near Detector complex prior to CD2. A corresponding milestone should be inserted prior to CD1.

10. Quantify the FTE effort, for the Near and Far Detector projects, of uncosted, and at present non-accounted for, Scientific effort that is necessary for the success of the project (e.g. Simulation and Software efforts). Incorporate into the baseline schedule prior to CD2.

# 3.0 Beamlines

## 3.1 Primary Beam

**Primary Writer: Rod Gerig**

**Contributor: Dave Johnson**

Overall the committee is impressed with the conceptual design work and progress on the LBNE beamlines. The work presented at this review focused on the changes due to the latest value engineering (VE) reconfiguration of the primary beam line and near site facility. Despite the limited scope (i.e not all level 4 tasks were presented), the work presented in many areas goes beyond what is required for CD-1 and reflects considerable thought and optimization. We were impressed with the content of the presentations. Findings and comments that are common to both the Primary Beams and Neutrino Beams are presented in section 3.1 along with those relevant to Primary Beams. Findings, comments and recommendations unique to neutrino beams are in section 3.2.

### Findings

- The initial design for LBNE primary and neutrino beams is for 700 kW. This is the operational level for NOvA operation, so there will be sufficient operational experience at these levels before LBNE construction begins.

- The design goal for many LBNE components is 2.3 MW

- Drill downs were performed in several areas including the target chase, reused magnets, reused power supplies, and installation.

- An overview of the Value Engineering of the beamlines portion of the project was presented which shows a reduction of overall project costs of $150M since November 2011.

- Several components are being repurposed from the Tevatron. These supplies and magnets will have sat in place for about a decade between their last utilization in the Tevatron and their use by LBNE. Also, in the case of the power supply, the LBNE application will be a fast ramp as opposed to the DC like operation in the Tevatron.

- A number of new magnets are being constructed for the primary beamline. These are based on existing Fermilab designs, and will be built using the same strategy as when they were built at Fermilab in the 1990's, and early 2000's. This involves procurement of coil sets, and punched laminations with final assembly at Fermilab.

- MoUs with the collaboration institutions have been established.

- A system integration task was presented that has identified responsibility for alignment, controls, interlocks, and installation coordination for the entire near site.

- The primary beam line length was reduced by ~148' and apex reduced by 10' through the VE exercise.

- The primary beam line shielding methodology allowed the reduction of the earth shielding from 25 to 23 feet. This modification has been accepted by the Laboratory after review and consideration of all mitigating factors.

- The quality of estimates for the primary beamline is largely engineering estimates based on similar items.

## Comments

- The beamline review committee unanimously wants to congratulate the members of the Beamline group of the LBNE Project for their continued efforts to development a well-established physics experiment. They have taken on a hard task of reducing the scope of the project so as to reduce the overall price. They have accomplished this task very professionally and in a very short time.

- The integration of the team as well as the cost loaded schedule is well developed.

- The accommodation for a possible upgrade to 2.3 MW operation as incorporated in the LBNE baseline is reasonable.

- The Value Engineering process as presented is detailed, well vetted, and well documented. The committee supports decisions made. It was not possible in the course of this review to determine if further VE efforts would be productive.

- The escalation tables leave little room for variances of material prices and salaries, and could present a risk if inflation picks up.

- The schedule is loaded toward the back of the project and leads to some uncomfortable manpower requirements and funding profiles. There is an unnatural reduction by a factor of 2 in engineering and technician effort in 2018 as compared to 2017 and 2019. This should be reevaluated.

- At this stage of design, the engineering estimate based on similar items is an adequate basis of estimate. It is expected that the quality of estimate will move toward a firm quote as the design moves into the final design stage.

- System integration level of effort at this stage of the project is appropriate. It is expected that the effort in this task would ramp up prior to the planned MI

shutdown due to the required detailed planning required for the shutdown. Currently the ramp up in effort is shown to be in the year of the shutdown.

- The matrix for the interfaces between level 4 tasks for the primary and neutrino beam line was presented during the March 2012 review. It has been extended to CF , ND, and MI. The project should continue to utilize this process.

- A significant amount of funding for repurposing of power supplies has been set aside. The committee endorses this approach.

- The optimization of the transport line to reduce its length is well thought out and the design appears to maintain a robust final focus. This optimization results in both technical component and conventional facilities costs savings of ~$80M, relative to the March review.

- The committee notes many common issues with the "Accelerator & NuMI Upgrades" (ANU) subproject of NOvA, relating to both technical and cost concerns. We encourage regular lessons learned dialog between ANU personnel and LBNE personnel to ensure all lessons learned from ANU are incorporated into the LBNE baseline.

## Recommendations

11. Conduct regular lessons learned dialog with ANU personnel to ensure that the cost estimates for LBNE incorporate the experience gained on ANU; and that the higher power operation of NOvA lessons are applied to LBNE.

## 3.2 Neutrino Beam

**Primary Writer: Peter Kasper**

**Contributor: Tony Gabriel**

### Findings

- The target for LBNE is based on the NuMI target design, applying lessons learned from the target failures during NuMI operation. There will be no joints in the cooling tube inside the target.

- LBNE is planning on using components from the NuMI beamline. Removing these components from the beamline is dependent on the termination of NOvA operation. There is an MOU in place with Fermilab noting the date (Jan 2020) at which NOvA operation ceases.

- The alignment and targeting tolerances are taken from NuMI rather than from LBNE simulations. Previous reviews have noted this as an issue.

- An analysis of the radiation levels and activation levels has been carried out.

- There is no detailed description, in the CDR, as to how the neutrino flux will be determined without a near neutrino detector.

- The additional requirements on the near muon detector, in the absence of the near neutrino detector have not been defined.

- The project has recognized the absence of the near neutrino detector and has appropriately addressed this in the risk assessment.

- The horn systems are based upon the NuMi design.

- Due to the VE exercise, the local hot cell, control room, and in-cell servo manipulator have been removed.

### Comments

- We concur that the NuMI target, as modified should meet the needs of LBNE. Currently, graphite will be used as the target material but beryllium is not being ruled out even though the cost is substantially higher and will have to be absorbed every time a target is changed out. Currently five target change outs a year are expected with graphite. Since beryllium can tolerate the radiation environment better than graphite, the cost will not be as large since few targets will be needed during the same run time. However, it is felt that the use of beryllium will still lead to higher operational cost. Based on past experience, the creation of nitric acid in the target and horn areas seems to be under control and erosion has been

minimized. In addition, the leak problem associated with the NuMI target has been corrected by using a continuous Titanium pipe around the graphite target

- The committee notes that given the timescale of the decision LBNE should have contingency plans if longer operation of NOvA is needed, including a milestone at which this decision needs to be made by.

- The committee believes that alignment tolerances taken from NuMI are considered adequate for LBNE. LBNE should continue the effort of deriving alignment tolerances from relevant simulations.

- Un-costed personnel could cause a problem in that some of these scientists may need to be paid to encourage them to carry out the required task. This problem is currently showing up in some of the analysis that has to be carried out concerning the neutrino beam and its relation with the target and the detector.

- The committee believes that the analysis of the radiation levels and activation levels is robust. In some areas such as the chase and berm additional analysis will be performed. The analysis of the thermal hydraulics is also adequate, and is being refined.

- Based upon the experience of the NuMi horn operation and reliability, the redesign of horn 1 to match the current NuMi design is appropriate.

## Recommendations

12. Provide, in the CDR, a description of how the neutrino flux is going to be determined. Document this by the CD-1 review. Following CD-1, provide an assessment of the impact on the performance specification of the near (muon) detector.

13. Consider funding the prototype of the near muon detector (and test in the NuMI beamline) prior to CD-2.

14. Due to the reduction of the remote handling capabilities, study remote handling failure modes and develop recovery techniques. Develop change-out procedures. Prepare these by CD-2.

# 4.0 Conventional Facilities

## Findings

- The CF is currently estimated at $247M (AY, no contingency) which is ~39% of the entire project estimate. There is a contingency of ~31% of the work to go carried on the CF.

- The CF plans for a CD-3a approval in March 2016 that would include placing the berm at the near site to allow a minimum of 12 months of settlement to occur. CF construction at the far site would be completed in late FY2019 and at the near site in early FY2021.

- Requirements are currently maintained in DOORS, where both engineering and programmatic requirements are recorded. LBNE develops the L2 and L3 requirements for the Near Site. For Far Site activities, SURF takes LBNE L2 and L3 requirements and decomposes them to align with one of 22 subsystems as part of their configuration management processes.

- As a result of DOE funding direction, major scope changes from the last review include removing Near Detector, reducing configuration and shielding at the near site beam line and moving the far detector to the surface.

- A risk register has been developed (all project upper level risks). Monte Carlo analysis was performed as part of a previous review; no plan to rerun analysis until just prior to the CD-2 review. CF Risks were updated with four new risks from last review (2 threats, 2 opportunities).

- As part of the reconfiguration a value engineering like activity was performed, although not a formal value engineering study. 20 different configurations were created at four sites, which resulted in significant scope reductions. For example, floor space of the near site target hall was reduced from ~46,000 GSF to 22,200 GSF.

- Project states that they can complete the NEPA documentation by the end of FY14, 18 months ahead of the planned CD-2/3a date.

- The project will not go for LEED certification but will incorporate sustainable guiding principles that have been developed.

- Project plans to augment existing staff by hiring an Agent CM at both the FNAL and the SURF sites.

## Comments

- Overall, CF is well documented and ready for CD-1 review.

- There is a lack of interface documentation and a plan for executing the interface process for the duration of the project. Interface responsibility matrix is being developed by "Beam Team"; however this matrix should be completed for all applicable portions of the project to ensure scope demarcations are adequately defined. It is recognized existing processes are in place that include technical group reviews of the drawings and approvals. This may not be an effective communication tool for capturing the requirements and interfaces. As a minimum, scope should be reviewed across the project before baselined to make sure there are no gaps.

- Suggest demonstrating planned layout of all technical equipment (e.g. LCW pump room) to validate room dimensions provide adequate space for egress, code clearances and maintenance.

- The estimate is an aggregate of multiple sources and, in many cases has been extrapolated by the LBNE team in various ways to reflect the current concept. This may be difficult to clearly demonstrate the basis of estimate to the ICR team. Cost drill down should be practiced by the team to ensure clear presentation of the information.

- Suggest that the Project present summary level cost factors ($/GSF and average daily construction rate) at the CD-1 Review. Also suggest that the CM costs be broken out and that staffing plans be presented.

- Project should carefully develop the NEPA project description to be broad enough to incorporate any credible scope alternatives.

## Recommendations

15. Prior to CD-1, a review should be conducted by all L2 project teams to review scope interfaces making sure there are no gaps and all assumptions should be recorded in the cost estimate.

16. While economies have been incorporated as the project scope has been revised, a formal VE effort should be conducted post CD-1 once the geotechnical investigations and the muon shielding simulations have been completed.

## 4.1 Near Site

**Primary Writer: Rebecca Yasky**

**Contributors: Jason Budd, Joe Harkins**

### Findings

- The Near Site CF scope of work includes the construction of LBNE 30 Absorber Complex, LBNE 20 Target Hall Complex, LBNE 5 Primary Beam Service Building, LBNE Primary Beamline Extraction Enclosure, Primary Beamline Enclosure & embankment, Decay Pipe with geomembrane barrier system and a relocation of an existing cooling pond. The Near Detector Hall has been removed from the LBNE project as a cost cutting measure.

- A presentation of beam line installation detailed that 95% of settlement occurs over the first 24 months. The project has requested long lead funds to achieve settlement prior to beamline enclosure installation. This could result in significant CF savings by reducing the current robust foundation design required to support the beamline.

- Regarding the geo-membrane system, Fermilab radiation health physicist performed a shielding assessment which drove decay pipe shielding thickness. There is a potential risk associated with temperature effects on the geo-membrane material, however preliminary analysis found that the current system is robust and is unlikely to be effected. Design also incorporates moisture/water mitigation and monitoring features to ensure tritium contamination does not leach into the surrounding ground water.

### Comments

- Vibration during construction may impact current Fermi operations; specifically CF will need to investigate and determine potential impact to the Main Injector operations. CF has stated they will coordinate with the users to inform them of the estimated vibration levels from the planned construction. CF is considering possible tests of construction vibration to calibrate sensitivity of main injector. This is considered good practice. Based on review recommendation tracker, CF plans to close this item by July 2014.

- Project has done a good job of handling potential water issues (e.g. geomembrane, pressure grouting and leak detection) at the Near Site to minimize the possibility of generating tritium in the ground water.

- Post CD-1, the Project may want to consider geofabric reinforcement to further increase the slope of the NS shielding berm to 1:1 for further cost savings to beamline embankment.

- If the development of the new cooling pond at the main injector was moved off project, it could be accomplished earlier than planned.

## Recommendations

17. Prior to CD-2, the project should consider having the construction of the cooling pond completed through a separate Fermilab funded project (e.g. IGPP). This would save both cost and schedule to the project and potentially minimize impact to operations.

## 4.2 Far Site

**Primary Writer: Jason Budd**

**Contributors: Joe Harkins, Rebecca Yasky**

### Findings

- The Far Site conventional facilities include an empty shell for experimental equipment to be installed within, access roads, support structures, and utilities. The Far Site conceptual design has the detector located in an excavated pit in the hillside with low angle muon shielding and the remaining structures at the surface level.

- The Far Site conceptual design requires land transfer of approximately 4 acres to State of South Dakota (SDSTA) from Barrick Gold Corp. Site (and equipment) donation terms are detailed in a Property Donation Agreement.

- The current surface location is driven by the requirement for the low angle muon shielding assumption. The previous surface location was a relatively level plateau and maintains the design of the detectors in series. In the current concept design, the detectors are in parallel. Location is close to the Oro Hondo fan/ventilation shaft.

- The Far Site has limited occupancy during operations. A control room will be located in an existing building at the Ross Campus for fire & security monitoring and remote control and monitoring of the cryogenic plant. Daily checks are planned to be performed of the cryogenic plant. Data acquisition for the experiment will be done remotely at either at Ross Complex at SURF or at the Near Site.

- Fire and life safety assessment reports have been developed for surface and below ground concepts at the Far Site.

- Cryogenics and Purification building square footage is based on requirements provided from the technical groups.

- No long lead funding is required for the Far Site. SURF MOU allows for some of the construction to be self-performed. Currently, the cost estimate includes a portion of the electrical distribution to be self-performed by SURF.

### Comments

- Current concept documentation for the Far Site conventional facilities is based on two previous underground concepts (800L and 4850L) and the previous NOvA detector project in Ash River, MN. Buildings and utilities are based on previous underground concept designs. The pit and detector hall are based on the NOvA

design and costs. Conceptual design documents for the Far Site are limited to site layout and the Detector Hall floor plan and cross sections. Prior to start of the preliminary design, the design for the Far Site needs further review.

- Current plan is to execute the work with two A-E contracts for the design effort and two construction contracts. Day to day management of these contracts will be by SURF. SURF has processes in place with the City of Lead involvement in design and construction of facilities that ends with a certificate of occupancy.

- The technical system requirements and interfaces for the Far Site CF should be documented similar to the Near Site. The LBNE Beamline Interface Matrix summarizes the requirements and interface for all the project subsystems at the Near Site.

- Oro-Hondo substation has sufficient capacity to meet the power needs for the Far Site facilities. No emergency power or backup systems are provided for the cryogenics plant. CF stated the cryogenics plant can manage a 2-3 day power outage.

- The Detector Hall roof concept design is based on NOvA. A structural engineer has said that the NOvA roof design and the combined dead and live load is basically equal to the dead and live load of the Detector Hall roof. The concept drawing indicates the roof capable of a 500 PSF live load prior to placement of aggregate. The roof shielding requirement is 2.7 g/cm3 and shown as 10 foot depth of excavated rock fill, plus the 4 foot thick concrete roof, on the concept drawings with the rock fill increasing to 30 foot depth at the stepped roof. The constructability of the shielding needs to be reviewed. Can the shielding density be achieved with the excavated rock? Can the roof design support the shielding placement operation?

- Based on a high level check of the costs per square foot, the direct costs for the Far Site Conventional Facilities appear reasonable. Suggest presentation of high level unit costs for the Far Site facilities similar to the Near Site presentation.

- Cost of excavation of the detector pit is based on NOvA controlled blasting costs of $215/cubic yard and the remaining site rock excavation is based on $85/cubic yard. The disposal of the excess excavated rock at a nearby site which needs NEPA review and approval. The estimated 65,000 cubic yards of rock is a potential cost driver if the current planned site is unavailable. Discussions with the State of South Dakota Department of Environment and Natural Resources indicate that this should not be problematic.

- The construction cost for Far Site includes $8,462K for construction management effort and staff of 13 FTEs. This is approximately 15% of the total construction costs and is reasonable.

## Recommendations

18. Prior to CD-2, validate the emergency power and/or power reliability requirements for the cryogenics plant.

# 5.0 Project Management

## 5.1 Cost

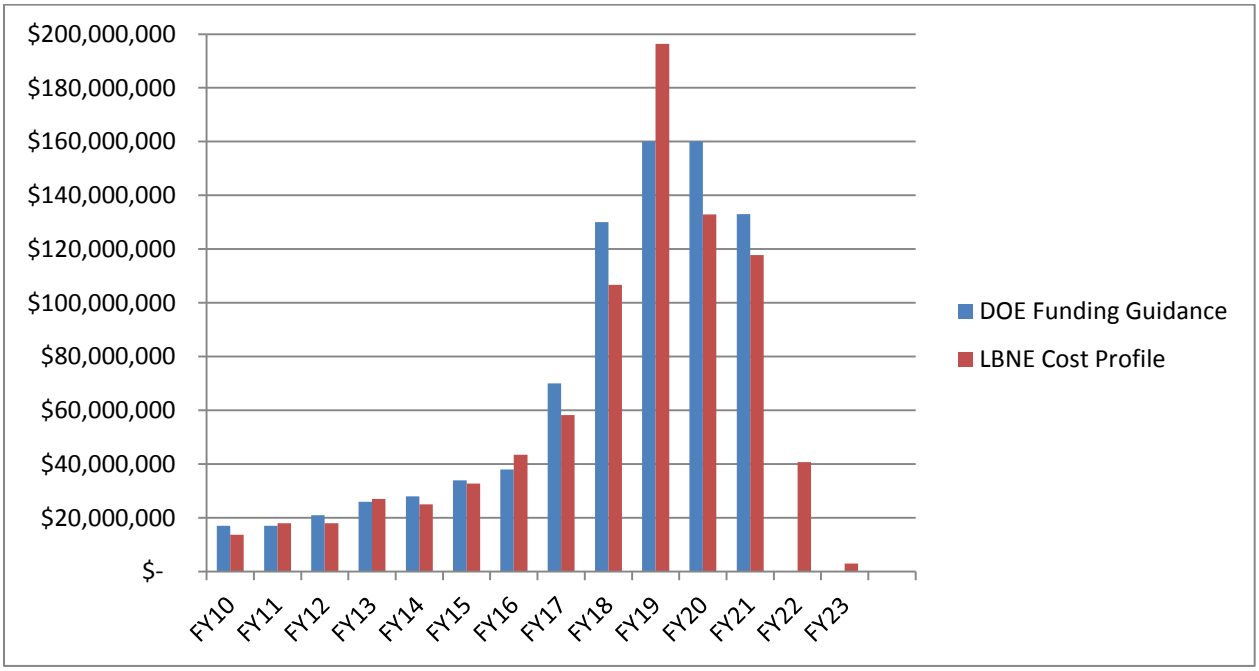
**Primary Writer: Elmie Peoples-Evans**

**Contributors: Diane Hatton, Sherese Humphrey, Pete Selgrad, All**

### Findings

- The LBNE Project has a TPC of $834M that includes $209.1M of contingency. The project has accumulated $45.8M in actual costs through June 2012. All costs were presented in $ FY12 and have been escalated forward.

- The contingency on the remaining work included in the point estimate is 36.1% and the project plans to increase this to 40% before the CD-1 review. The LBNE funding profile is provided below.




- The LBNE Project has 91 control accounts which are managed by 44 CAMs (Control Account Managers). The project plans to collect costs at L2-L5 of the WBS.

- The LBNE Project has over 120 BOEs (Basis of Estimates) that have been recently updated and reflect the cost of work to complete the project going forward from June 2012.

## Comments

- The LBNE Project Team has done a good job with re-planning the project after the recent reconfiguration.

- The LBNE Project Team is utilizing the good project management tools and processes that are currently in place at Fermilab.

- The project presented detailed costs estimates with supporting documentation appropriate for this stage of the project. However, we did find some areas where the cost estimates could benefit from some fine tuning.

- The cost estimate for the far site is not as mature as other parts of the project. The LBNE project team should review the cost drivers for the far site as a sanity check in order to look for opportunities for cost reduction.

- The committee found that not all of the uncosted labor effort has been clearly identified within the estimate. This should either be adjusted in the areas where there are known issues and/or as an increase to the risk associated with this area.

## Recommendations

19. LBNE CAMs need to refresh their knowledge and understanding of the cost estimate. They should take ownership of their estimates and be able to speak confidently in support of those estimates. Conduct regular practice sessions between now and the CD-1 review.

20. Adjust areas of the cost estimate where there are known issues with uncosted labor.

## 5.2 Schedule

**Primary Writer: Sherese Humphrey**

**Contributors: Diane Hatton, Elmie Peoples-Evans, Peter Selgrad, All**

### Findings

- The LBNE Project schedule contains 5,127 activities.
- There is an average of 3.5 project controls FTEs per year assigned over the life of the project.
- The schedule presented by the Project team is currently funding constrained.
- Sub-project interfaces are established in the schedule. These interfaces are reflected as critical decisions, review preparation, and beneficial occupancy, for example.
- A nine-month review period is planned for CD approvals.
- The total number of critical activities is 398. Critical activities have been defined as activities with total float of less than 0.8 days.
- The critical path runs through the CF design and the Far Site Construction.
- One year of schedule float is planned to the CD-4 completion.
- Many activity durations exceed a two-month period.
- Open-ended activities exist within the schedule: 35 activities without predecessors, 140 activities without successors, and 96 activities that are constrained. The bulk of activities with open relationships fall under WBS 130.04, Water Cherenkov.
- There are discrete activities that have a mixture of labor and M&S cost.

### Comments

- The beamline installation schedule includes a significant amount of detail for this stage of the project, but it does not yet tell a coherent story. This should be further refined.
- WBS 130.04, Water Cherenkov, contains open logic that is found when diagnostics are run on the schedule. Even those these activities are completed, we believe that correcting this should be relatively easy and that it should be done as good schedule practice.

- Between now and CD-2, activities with durations exceeding a two-month period should be further refined.

- Discrete activities with a mixture of labor and M&S should be separated prior to setting the baseline.

## Recommendations

21. Fix open logic within the schedule prior to the CD-1 Review and confirm that all deficiencies of open logic have been corrected.

22. Ensure that the schedule snapshots given to the review team are consistent. Filter out the funding obligation activities that are related to the budget obligation profile so that CAMs speak to baseline cost.

23. Independently assess and track the critical path for the near and far site.

24. Too much emphasis was placed on the timing of CD reviews and approvals. The project team needs to find ways to proceed more quickly.

25. LBNE CAMs need to refresh their knowledge and understanding of the schedule. They should take ownership of their estimates and be able to speak confidently in support of those estimates. Conduct regular practice sessions between now and the CD-1 review.

## 5.3 Management

**Primary Writer: Ken Stanfield**

**Contributors: Marc Kaducak, Ron Ray, All**

### Findings

- On March 19th, 2012, Dr. W.F. Brinkman, Director of the DOE Office of Science, asked Fermilab to find a path forward to reach the goals of the LBNE in a phased approach or with alternative options. Pier Oddone, Director of Fermilab, formed a Steering Committee from the US HEP community to address this request. The Steering Committee considered several options and recommended a phased LBNE with a first phase to include a surface LAR detector at SURF, a new beam at Fermilab, and system of muon detectors rather than a near neutrino detector to monitor the beam. The project considered at this review has as its scope this reconfigured LBNE project.

- The proposed reconfigured LBNE Project has a base cost estimate of $624.9M in AY$. A contingency of 36% on remaining work has been allocated for a Total Project Cost of $834M. Costs to date (through 6/2012) total $45.8M. The funding profile provided by DOE began in FY2010 and stretches out over 12 years to FY2021. This profile is very back-end loaded with its peak years in FY2019 - 2020. The proposed schedule has an early completion date of June 2023 and a CD-4 date of June 2024 so that there are 12 months of schedule float.

- The LBNE Project is led by Project Director Jim Strait and Project Manager Elaine McCluskey.

- Key Performance Parameters have been developed in consultation with DOE and are described in a draft Preliminary Project Execution Plan. These will be reviewed and perhaps revised prior to CD-2.

- The project has developed a TPC Cost Estimate range of from $719M to $1020M. This was done following an Association for the Advancement of Cost Engineering (AACE) method recommended by DOE G 413.3-21. The Project applied an Estimate Range to the Point Estimate (TPC including contingency) at the Subproject Level based on design maturity after determining the project definition for each Subproject, post reconfiguration.

- An analysis to develop the required schedule range for CD-1 was not presented.

- The Project has developed a Risk Plan and a register with 45 entries. The contingency is based on a bottom up approach with 2 components, one based on maturity of design and the other based on the risk analysis. An additional top down analysis will be completed by the October DOE CD-1 review which is expected to yield a total contingency of ~40%.

- A well-developed resource loaded schedule has been prepared employing the Primavera P6 tool. It is linked, integrated and the resulting plan has been iterated to meet the DOE funding profile.

- The resource loaded schedule predicts the staffing requirements across the various labor types needed to complete the project. Currently, the project is fully staffed down to L3 with the exception of the Quality Assurance manager. A Staffing Plan has been made to meet the identified requirement for FY2013. The full Staffing Plan over the life of the project will be developed prior to CD-2.

- A comprehensive Conceptual Design Report has been prepared for the reconfigured LBNE Project.

- The SURF laboratory in South Dakota is a key member of the LBNE team. They will manage the conventional construction activity at their lab site, including the ES&H oversight, under contract with Fermilab. An MOU has been prepared with SDSTA/SURF, LBNL, and Fermilab. LBNL provides DOE operating funding to SURF.

- The Project has developed a Procurement Management Plan and will develop Advanced Procurement Plans for key procurements. A dedicated procurement manager was recently added to the project team.

- An extensive program of Value Engineering has been undertaken and is documented.

- Like many DOE Office of Science projects LBNE has many university and other laboratory participants. They play a major role in designing, constructing and eventually operating the experimental equipment such as the LBNE LAR far detector. The effort of these scientists is by Office of Science policy not funded by the project as they are funded as an off-project contribution from their home institutions. However, some of the activities of these scientists are required by the project in the design of project components. Examples of this are the simulations needed to design the neutrino beam line. The effort to perform these simulations has not yet been fully identified.

- The Project has identified scope contingency in the event that adverse cost experience requires this to deliver the project within its budget.

- A Life Cycle Cost analysis has been completed including the consideration of alternatives.

- The plan is for SURF to manage ES&H and CM activities on their site. The plan is then for responsibility to transfer to Fermilab at Beneficial Occupancy when the site falls under DOE control by virtue of a lease agreement with SDSTA. Hence, the plan is for Fermilab to manage the installation of the far detector including ES&H oversight of those activities.

- Power Point presentations at this review followed a consistent outline and format.

- The Project organization structure is well aligned with a well-developed Work Breakdown Structure. The WBS is organized around deliverables.

- The Project has a small dedicated Project Management Team and the Project Director reports to the Fermilab Director. Because of the large number of institutions participating and the organization structure of these participants the remainder of the project Staff is provided employing a shared or "matrix" approach. The project employs MOUs and agreements which are coupled to their Staffing Plan to identify the necessary project Staff.

- The LBNE Project intends to reuse existing equipment from the NuMI beam line and the Tevatron.

- The project employs a Systems Engineering approach including Configuration control. The Configuration Management Plan has been developed. There is a well-organized set of requirements with flow down to system design. Change Control and Interface Control methodologies are employed.

- A Quality Assurance plan with a graded approach has been prepared.

- Project tools are in use to support project planning, e.g. the resource loaded schedule using Primavera P6 and Cobra for cost reporting. An EVMS based on the certified FNAL system will be implemented prior to CD-2.

## Comments

- The project Team led by Jim Strait and Elaine McCluskey is very strong, capable, competent, committed and experienced. Team bios were available for all leaders down to L2. The Project reports to the Fermilab Director. This team is fully capable of delivering the LBNE project scope within budget and on schedule.

- Presentation of the project organization structure should be sharpened, especially as regards the role of SURF in the LBNE project. This should focus on the organization chart for the project which is aligned with project deliverables. There were several charts presented depicting the role of SURF. These are potentially confusing taken as a whole.

- It is a good plan for SDSTA-SURF to manage the conventional construction for the far detector so that they maintain control of their site through this phase of the project.

- A breakout presentation should be prepared describing the LBNE procurement function. This should include a discussion of the Advanced Procurement Plans.

- The determination of schedule float is not yet risk based; this is determined in a top down fashion. There is a plan to develop schedule contingency based on risk consideration before CD-2.

- Consider developing and maintaining a technically limited project integrated plan for the purpose of studying, understanding and communicating how the project schedule might be accelerated.

- Reconsider when to apply risk in the process of developing the cost range. Avoid overstating the size of the range.

- Risk analysis is advanced for this stage of the project. In the presentations differentiate between the top down contingency analysis and the (bottom-up) risk based portion of the contingency analysis.

- The status of project tools in general is well advanced for this stage of the project. They are in use now to support project planning and decisions.

- The base estimate of $624.9M is judged to be reasonable. A contingency allocation of 40% is adequate for this stage of the project.

- There is a plan for projected staffing need and the project is on track for FY13. A Plan for the source of labor for the duration of the project should be in process by CD-1 and fully developed by CD-2.

- The recent reconfiguration of the project scope following the recommendation of the Steering Committee has been well executed yielding a revised scope that satisfies the performance requirements recommended by the LBNE reconfiguration steering committee. This was accomplished in a short time frame.

- The use of planning tools such as MOUs and annual agreements for identifying the required staff is important when managing a large, complex project with a large number of institutions participating and where those institutions assign staff part time for specific tasks.

- The Project should identify soon the necessary "un-costed" scientific effort to complete the beam line and other simulations. These "un-costed" activities which are, none the less, required for project success should be included in the project plans, e.g. as tasks in the integrated schedule.

- The practice of using a standard presentation format with a standard outline is noteworthy and helpful to the review committee. Take care that all slides that follow from this approach contain useful information for each talk.

- The team understands the requirements for activities and documents for CD-1. Good progress has been made; all activities and documents are in process for

completion by the DOE CD-1 review. The March 2012 Director's Review served (in part) as the independent design review for the full scope of LBNE prior to reconfiguration; this Director's CD-1 Review serves (in part) as the Independent Design Review covering the changes that resulted from the reconfiguration. This been completed but this was not presented as such in the CD-1 requirements check list provided.

- The risks associated with the reuse of existing equipment should be well understood and incorporated into project planning, including for example: availability, reliability, refurbishment, and testing.

- Consider benchmarking the effort dedicated to Project Management for LBNE with other similar sized projects.

## Recommendations

26. The current funding profile guidance for the LBNE project is back-end loaded with FY 2021 the final funding year and the peak occurring only in the preceding two years. In this challenging situation project management should develop an aggressive approach to managing the schedule. Work with DOE to use the flexibility that exists within the Critical Decision process to achieve the earliest possible completion date. Also, work with DOE to improve the funding profile and to advance key procurements and activities.

27. Presentations should emphasize that the reconfigured LBNE project provides the increased research capabilities envisioned in the CD-0 mission need statement and that it satisfies the performance requirements recommended by the LBNE reconfiguration steering committee.

28. Complete and present an analysis to determine the range of schedule completion dates prior to CD-1.

29. The Project has a strong team and is nearly CD-1 ready. Complete the documents required for CD-1 and proceed as planned to the DOE CD-1 Review in October.

## 5.4 ES&H

**Primary Writer: Jim Lang**

**Contributors: Gina Dixon-Roemer**

### Findings

- Drafts or approved versions of the ES&H Documentation requirements for CD-1 have been prepared.

### Comments

- Radiological considerations have been addressed thoroughly and conservatively for this stage of project planning.

The LBNE ES&H Manager is well integrated into the processes associated with preparations for CD-1 and has directly relevant experience.

### Recommendations

30. Formal QA presentations are recommended for the CD-1 review

31. Level 2 Presenters should incorporate ES&H and QA slides in their plenary presentations.

32. The LBNE QA plan should include the process for integrating the QA plans of SURF and the contributing DOE Laboratories.

33. SURF has a QA plan for design but does not currently have a QA plan that includes construction, installation or operations. LBNE should determine if a more global SURF QA plan would be appropriate.

34. NEPA: Consider completing an EA (with a FONSI based on mitigation of identified impacts) as opposed to a hybrid EA/EIS approach.

35. We recommend fast-tracking the resolution of the most critical NEPA-related elements.

36. CD-1 requirements have been met by evaluating the applicability of LEED and DOE Guiding Principles. Reviewers recommend that planning continue to incorporate sustainable design elements, although LEED is not directly relevant to the planned new construction.

# 6.0 Charge Questions

### 6.1. Does the conceptual design satisfy the performance requirements?

Yes, pending success on the following activities: a) affirmation by the forthcoming technical review addressing far detector performance operating on the surface. b) Demonstration that the Near Detector Complex and associated NuMI validation measurements can meet the requirements of the LBNE research program. This demonstration should in the LBNE Conceptual Design Report.

### 6.2. Can the design be constructed, inspected, tested, installed, operated and maintained in a satisfactory way?

Yes for detector systems pending inclusion of additional risk mitigation scope required for the conceptual design to satisfy the performance requirements (see 6.1). Examples include: far detector calibration systems, near neutrino-detector, etc. Yes for beamline system In spite of some reduction in the remote handling capabilities (as Part of the VE exercise). Yes for Conventional Facilities.

### 6.3. Has value engineering been performed as part of the design development and has it been documented?

Yes, for this stage of the project. Value Engineering (VE) has been performed through multiple cost cutting measures, however the Project plans to conduct a formal VE session covering the entire project after the CD-1 review. A separate, formal VE session covering just the CF scope at the CF 60% preliminary design stage will also be performed.

### 6.4. Is there adequate documentation to support the conceptual design, which will allow the transition to developing the preliminary design?

Yes, after addressing the documentation recommendations regarding the near detector.

### 6.5. Has the Project developed a quality resource loaded schedule? Has all the work been appropriately identified, estimated and scheduled?

Yes. The project has developed a quality resource loaded schedule for this point in the project life cycle. Work has been identified, estimated, and scheduled at a level that is appropriate. Some areas require further refinement, but the level of detail is adequate for a CD-1 review.

### 6.6. Is the estimated cost range and project duration realistic, consistent with the technical and budgetary objectives, and justified by the supporting documentation? Have assumptions been included in developing the proposed cost and schedule range, and are they documented?

Yes. The project cost range is realistic given the constraints and is justified appropriately by the supporting documentation. The project duration, however, is long and the project team needs to work to find ways to take advantage of opportunities to proceed more quickly. Overall, assumptions have been taken into account when developing the cost and schedule range and they are documented.

### 6.7. Has a life-cycle cost estimate been performed, documented, and does it address alternatives? Has the selected alternative been adequately justified on the basis of cost, schedule, and scope?

Yes. A detailed life-cycle cost estimate was developed and documented, addressing the three alternatives. The selected alternative was chosen based a number of important factors, of which life-cycle cost was one of them. Although the chosen alternative is somewhat more costly than the other two alternatives, scientific considerations were such that the selected LBNE alternative was deemed the most appropriate given all of the factors that were considered.

### 6.8. Has the Project implemented a Risk Management Process by identifying risks, performing a risk assessment and started developing mitigation plans at an appropriate level for the CD-1 stage?

Yes.

### 6.9. Does the Project Team have adequate management experience, design skills and laboratory support to produce a credible technical, cost and schedule baseline?

Yes.

### 6.10. Is the current staffing level adequate to complete the work to achieve CD-2? If not, has the appropriate staffing level been identified in the schedule and has a staffing plan been developed to acquire the future staffing needs?

A qualified yes. The plan for acquiring staff exists for FY 2013. There is a plan to address FY 2014 and out-years before CD-2.

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

Yes.

### 6.12. Has the project acceptably addressed the relevant recommendations from the Director's Review conducted in March 2012?

Yes. An up-to-date log was presented including responses to the March 2012 review and all other internal and external reviews to date.

### 6.13. Is the documentation required by DOE O 413.3B in order and is the LBNE Project ready for a DOE CD-1 review at the end of this October?

Yes. The LBNE Project will be ready for the DOE CD-1 review at the end of this October. Most of the required documents are complete and the few that are still in process will be completed prior to the review.