

Critical Decision 1
Approve Alternative Selection and Cost Range
of the
Long Baseline Neutrino Experiment (LBNE) Project
(Line Item Project 11-SC-40)
at the
Fermi National Accelerator Laboratory and
Sanford Underground Research Facility
Office of High Energy Physics
Office of Science

Purpose

The purpose of this paper is to document the review and approval by the DOE Office of Science Energy Systems Acquisition Advisory Board-equivalent for Critical Decision 1 (CD-1) “Approve Alternative Selection and Cost Range” for the Long Baseline Neutrino Experiment (LBNE) Project at the Fermi National Accelerator Laboratory (Fermilab) and Homestake Mine site in Lead, South Dakota.

Project Overview

The purpose of the LBNE Project is to design, construct and install an intense neutrino beam at Fermilab in Batavia, IL and a large neutrino detector located at the Homestake Mine site 1,300 kilometers away in Lead, SD. The neutrino beam is directed toward the detector, which is used to measure and study neutrino behavior over the long distance of travel, to yield fundamental knowledge about neutrino properties.

The High Energy Physics (HEP) program of the DOE Office of Science (SC) conducts basic research into the nature and interactions of the fundamental constituents of matter. As the only US Laboratory fully dedicated to particle physics, Fermilab is a major component of the US HEP Program. The LBNE experiment will use the accelerator facility at Fermilab to investigate neutrino oscillation, mass ordering and matter-antimatter asymmetry, which requires the combination of large detectors and more powerful beams capable of observing neutrino interactions where the beam and detector(s) are separated by 1000-1500 km.

The LBNE Project will provide U.S. researchers the opportunity to maintain and enhance a world-leading program in neutrino physics and support DOE HEP's strategic plan to mount a balanced and vital U.S. program in particle physics in the next decade. Without the research capabilities implemented in this project, crucial information fully characterizing the neutrino sector such as the degree of Charge-Parity (CP) violation and the ordering of the neutrino mass states, would not be obtained, compromising the ability to understand the matter-antimatter asymmetry and resulting dominance of matter in the universe.

To meet the scientific and technical objectives for the LBNE experiment, the following draft key performance parameters have been developed.

Description of Scope	Threshold Key Performance Parameter (KPP)	Objective KPP
Primary Beam Power to produce neutrinos directed to the far detector site	Capable of delivering 700 kiloWatts , with beamline hardware commissioning complete.	
Long-Baseline Distance between neutrino source and far detector	1,000-1,500 kilometers	
Liquid Argon Far Detector	Operational capability installed for a 10 kiloton detector and demonstration of threshold performance by observation of cosmic ray interactions.	Additional detector mass and/or underground siting, facilitated by non-DOE in-kind contributions
Near Detector	Tertiary Muon Detector components tested in NUMI beam.	Near Detector facilitated by non-DOE in-kind contributions

Alternative Selection

In March 2012, the Director of the DOE Office of Science asked Fermilab to lead development of an affordable and phased approach to LBNE, including alternate configurations that will enable important science results. Various options were assessed and three viable configuration alternatives were identified that could establish the LBNE Project within the requirements, i.e. to enable important science consistent with mission need and within target cost range. The three primary alternatives considered were:

1. Construct a new low energy LBNE beamline with a 10 kton liquid argon time projection chamber (LAr-TPC) surface detector at the Homestake site in South Dakota, 1,300 km distant from Fermilab.
2. Use the existing Fermilab NuMI beamline in the low energy configuration with a 30 kton LAr-TPC surface detector 14 mrad off-axis at Ash River in Minnesota, 810 km baseline distance from Fermilab.
3. Use the existing Fermilab NuMI beamline in the low energy configuration with a 15 kton LAr-TPC underground (at the 2,340 ft level) detector on-axis at the Soudan Lab in Minnesota, 735 km baseline distance from Fermilab.

The primary considerations in evaluating the alternatives were: ability to meet mission need; technical considerations; scientific capability; site conditions and location (e.g. longer distance baseline and proximity to deep underground location for possible future enhancements) and potential for attracting additional resources external to DOE to support possible future enhancements and a broader based physics program in support of mission need.

Based on the above considerations, the alternative, *Construct a new low energy neutrino beamline with a 10 kton liquid LAr-TPC surface detector at Homestake site in South Dakota, at a 1,300 km baseline distance from Fermilab*, is the recommended alternative for LBNE. This preference is driven by the scientific advantages of a longer distance baseline between the neutrino source and detector afforded by siting the detector on the Homestake site. This alternative requires a new neutrino beamline to meet the necessary beam directional, energy and long-term operability requirements needed to initiate and sustain the LBNE program. This

alternative provides the best alternative to realize a timely, cost-effective and scientifically capable LBNE, and provides a solid foundation for cost effectively extending scientific reach should additional funds become available.

Critical Decision 1 Requirements

All prerequisites for CD-1 approval have been completed for the LBNE Project:

- Acquisition Strategy—submitted;
- Conceptual Design Report and Review—completed;
- Preliminary Project Execution Plan—submitted;
- Integrated Project Team—chartered and functioning (included in PPEP);
- Risk Management Plan—completed;
- One-for-one Replacement for Building sq. footage—addressed;
- Preliminary Hazard Analysis Report—completed;
- ISM implementation—ISM Plan for LBNE developed, documented and implemented
- Environmental Documentation—NEPA determination for an EA approved on Sept. 21, 2012;
- High Performance Sustainable Building—applying DOE Guiding Principles as applicable;
- QA Program—outlined in PPEP and in LBNE Quality Management Plan.

Preliminary Cost Range

The Total Estimated Cost (TEC) for the LBNE Project is estimated to be in the range \$731 million to \$1,027 million in then-year dollars. The DOE Total Project Cost (TPC) is estimated to be in the range \$805 million to \$1,110 million in then-year dollars. Current estimates are that the Project could be baselined at \$867 million in then-year dollars.

The DOE-SC Office of Project Assessment (OPA) at the request of the Acquisition Executive conducted a review to validate the LBNE conceptual design and cost range for CD-1 on October 31-November 1, 2012. A joint Independent Cost Review was also conducted by DOE Office of Acquisition and Project Management and concluded on November 7, 2012. The project and documentation were reviewed and judged to be ready for CD-1. Subsequent to the review and in response to review recommendations, the cost range was updated in the Preliminary Project Execution Plan and Acquisition Plan with the information presented in the tables below.

DOE Cost Range (\$ in Millions)	
DOE TEC	731 – 1,027
DOE OPC	74 – 83
DOE TPC range	805 – 1,110

Table 6.0 LBNE Planned Funding Profile (\$ in Millions)

Fiscal Year	Prior Yrs	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	Total
PED		4	16	33	44	48							145
Construction							73	121	155	157	110	32	647
OPC	34	17	10									14	75
Total	34	21	26	33	44	48	73	121	155	157	110	46	867

Key Milestones and Events

The following table shows the preliminary key milestones. The CD-0 milestone date is an actual date, and the future dates are the estimates from the Integrated Project Team (IPT) of the planned schedule.

Critical Decision Milestone	Schedule
CD-0 Approve Mission Need	1/8/2010 (Actual)
CD-1 Approve Alternative Selection and Cost Range	1 st Quarter, FY2013
CD-3a Approve Long Lead Procurement	3 rd Quarter, FY2015
CD-2 Approve Performance Baseline	3 rd Quarter, FY2016
CD-3b Approve Start of Construction	3 rd Quarter, FY2017
CD-4 Approve Project Completion	3 rd Quarter FY2025

Tailoring

A phased CD-3 approval is planned, consisting of CD-3a for long-lead procurement items to reduce schedule and cost risks, and CD-3b for construction start for the full project. CD-3a is planned for approval prior to CD-2. Planned long lead items include site preparation to place the near site beamline embankment at Fermilab to allow settlement time before start of beamline construction.

Tailoring of the scope definition prior to CD-2 to enhance scientific capabilities may also be considered. The physics opportunities offered by the beam from Fermilab and the long baseline may attract the support of other agencies both domestic and international. Contributions from such other agencies offer alternative funding scenarios that could enhance the science capabilities of the Project. If additional domestic or international funding commitments are secured sufficiently prior to CD-2, the DOE LBNE Project baseline scope could be refined before CD-2 to include scope opportunities such as a Near Neutrino Detector complex at Fermilab or an underground location at SURF for the far detector.

DOE Review

The DOE-SC OPA conducted an Independent Project Review on October 30-November 1, 2012 to assess the LBNE Project’s readiness for CD-1 approval. The review found that the LBNE Project has developed a credible conceptual design and associated cost and schedule ranges. The review did not find any significant technical issues with the proposed project plan, but made key

recommendations regarding the cost range. The review committee found the Project to be ready to seek CD-1 approval upon addressing key recommendations and finalizing CD-1 documentation, which has been completed.

Acquisition Strategy

An Acquisition Strategy has been submitted for approval as a prerequisite for CD-1. Briefly, the Acquisition Strategy describes why Fermi Research Alliance (FRA) has been selected to lead the project based on its existing scientific and engineering expertise, the need to involve the collaborating physicists in the design and construction, and to simplify the interfaces among the collaboration, the project, and the rest of the lab.

FRA and Fermilab, through the LBNE Project based at Fermilab, is responsible to DOE to manage and complete construction of the LBNE facility and detector configuration at both the near and far site locations. In leading the LBNE Project, Fermilab will collaborate and work with many institutions, including DOE National Laboratories (BNL, LANL, LBNL), dozens of Universities, SURF and the South Dakota Science and Technology Authority (SDSTA). FRA and Fermilab are responsible for oversight of all contracts required to execute the project. These contracts are expected to include the purchase of components from vendors as well as contracts with collaborating institutions to fabricate some of the subsystems, and with SDSTA for far site construction management and construction.

The IPT reviewed and evaluated the feasible acquisition alternatives, taking into account Fermilab's extensive in-house capabilities and the capabilities of institutions participating in the scientific research collaboration. The primary source of materials for these projects will be commercial vendors vying for purchase orders under competitive conditions. Several components will be provided by collaborating universities and DOE Labs. It is anticipated that Fermilab will issue fixed-price contracts. Some sole-source fixed price procurements of one-of-a-kind equipment or services may be necessary in cases where only one qualified bidder exists. All actions will be in accordance with the DOE approved procurement policies and procedures.

Environmental Strategy

The NEPA determination for the LBNE Project was approved on September 21, 2012 recommending an Environmental Assessment (EA) be prepared on the LBNE Project. The LBNE NEPA team is comprised of members from DOE-CH, FSO, Fermilab, LBNE Project, SDSTA/SURF and other contractors supporting the NEPA effort. The LBNE NEPA team holds regular coordination meetings to address and resolve issues related to scoping, technical approach, schedule, public outreach, and other matters concerning EA preparation and National Historic Preservation Act (NHPA) compliance.

Risk Management

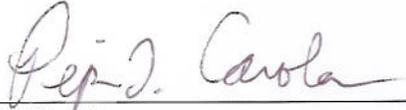
Risks identification has begun. The Project will manage risk according to its formal Risk Management Plan. Risks are identified based on probability of occurrence and impact/consequence. LBNE Project management reviews the results and classifies the risks as high, medium, or low based on a Risk Classification Matrix. Project risk is mitigated through a

structured and integrated process for identifying, evaluating, tracking, abating and managing risks (opportunities are evaluated and managed through the same process).

The critical risks and mitigation plans identified at the time of the LBNE CD-1 review are documented in detail in the Preliminary LBNE Risk Registry. This Risk Registry will be tracked and updated by the LBNE Project Office as a living document to assure that the risk mitigation has adequate management oversight. The estimated costs and contingencies to mitigate these risks are incorporated in the Project's preliminary cost and schedule ranges. Early phases of the LBNE design process are structured to identify risks, which are addressed through design improvements, advanced procurement planning, prototypes, schedule and cost contingencies.

**Critical Decision 1, Approve Alternative Selection and Cost Range
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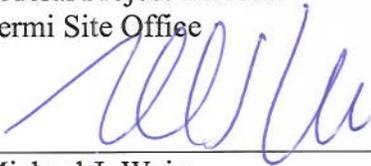
Submitted by:



Pepin T. Carolan
Federal Project Director
Fermi Site Office

11/27/2012

Date



Michael J. Weis
Site Manager
Fermi Site Office

11/27/2012

Date



Michael Procario
Program Manager
Office of High Energy Physics

11/27/2012

Date



James L. Siegrist
Associate Director for High Energy Physics
Office of Science

11/29/12

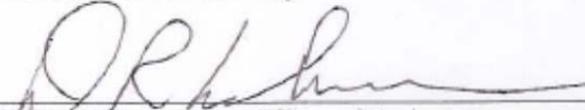
Date

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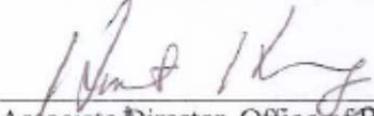
Recommendations:

The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-1, Approve Alternative Selection and Cost Range, for the LBNE Project at Fermilab and Homestake Mine site as noted below.

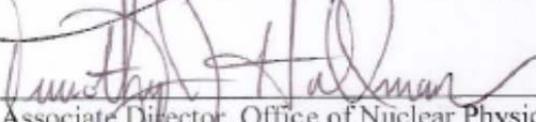
Director, Office of Budget
Date Yes ___ No ___

 12/10/2012

ESAAB Secretariat, Office of Project Assessment
Date Yes No ___

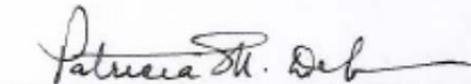
 Dec. 10, 2012

Associate Director, Office of Basic Energy Sciences
Date Yes No ___

 Dec 10, 2012

Associate Director, Office of Nuclear Physics
Date Yes No ___

Deputy Director for Field Operations
Date Yes ___ No ___

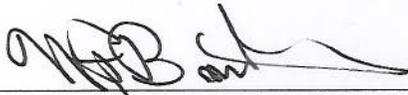
 12/10/2012

Deputy Director for Science Programs
Date Yes No ___

**Critical Decision 1, Approve Alternative Selection and Cost Range
for the LBNE Project**

Approval

Based on the information presented in this document and at the ESAAB review, I approve Critical Decision 1, Approve Alternative Selection and Cost Range for the Long Baseline Neutrino (LBNE) Project.



William Brinkman, Acquisition Executive
Director, Office of Science

12/10/12

Date