

**DOE Mini-Review of the
Neutrinos at the Main Injector (NuMI) Project
February 17, 2005 ~ Fermi National Accelerator Laboratory**

Summary

Robin Staffin, Associate Director for the Office of High Energy Physics, requested that the Office of Project Assessment, perform an on-site review of the Neutrinos at the Main Injector (NuMI) project at Fermi National Accelerator Laboratory (Fermilab) on February 17, 2005 (see Attachment A, Charge to the Committee). The purpose of the review was to judge the project's readiness to proceed to Critical Decision 4 (CD-4), Approve Start of Operations. General prerequisites for CD-4 were given in DOE Manual 413.3-1, Section 7.9.1. The Committee was asked to assess the status of the project with respect to both these general prerequisites and the NuMI project acceptance checklist (Attachment B), developed by the Federal Project Director.

The Committee was chaired by Steve Tkaczyk, Office of Project Assessment. The review attendees are shown below:

DOE
Steve Tkaczyk, Chair
Richard Imlay, DOE/SC
Stephen Webster, DOE/FSO

Consultant
Rod Gerig, ANL

Observers
Ron Lutha, DOE/FSO
Frank Gines, DOE/ASO

Based on the observations documented in the following sections, the Committee concluded that the NuMI project has met all CD-4 requirements and therefore recommends approval of CD-4.

1. Technical and Conventional

Conventional work on the project was completed in October 2003, and at that time the NuMI project accepted ownership of the facility. The remainder of this section will focus on the technical components, although several comments are made regarding facility readiness. The Committee was asked to evaluate seven prerequisites (see Attachment B).

Verification of Performance Criteria

The Committee was presented with the six following accelerator and detector performance criteria:

1. Proton intensity on target greater than 1×10^{12} per spill
2. Beam alignment to the MINOS far detector at better than 1 mrad
3. Neutrino beam energy monitored in the 2-4 GeV range
4. Cosmic rays detected in the MINOS near detector
5. Observation of neutrinos produced by NuMI beam in near detector
6. Cosmic rays and atmospheric neutrinos detected in the two MINOS far detector Supermodules

Two commissioning periods were made available to NuMI. The first was an initial trial with beam in late 2004, and the second was a more extensive period on January 21-23, 2005. Results of the accelerator studies, as related to these goals, were presented at the review. The Committee noted the techniques used to measure these goals, and was satisfied that the project had demonstrated their successful completion. With respect to accelerator performance, during a majority of this commissioning time, the Main Injector provided in excess of 2.5×10^{12} protons per spill on target. The beam angle to the MINOS far detector was monitored and verified to an angle better than 50 microradians.

Operations Readiness Review (ORR) and Safety Assessment Document (SAD)

The NuMI project has been proactive in its approach to operational readiness. The ORR process began in October 2002; involved many NuMI staff, DOE safety experts, and outside consultants; and culminated in November 2004. The reviews were not limited to presentations, but also involved on-site inspections. The Committee reviewed the ORR committee report, and was satisfied that the review was thorough. Furthermore, all recommendations from the ORR committee have been responded to by the NuMI staff and were documented in the review material. The Committee noted that a significant emphasis of the readiness process is to approve the SAD. The documentation presented indicated that the review of the SAD was also thorough, involving dialog, recommendations, and responses. The Committee was confident that the review was complete and that a final approved SAD is in place.

The Committee was also presented with the assessment of facility readiness. This assessment was also thorough, addressing the handoff from the NuMI project to laboratory management of facilities. The readiness of specific facility systems is satisfactorily addressed.

Operating and Maintenance Procedures, Trained and Qualified Staff, and Transition to Operations

The project noted that NuMI is already integrated into the other programs that Fermilab operates (such as the MiniBooNE program). Where different (e.g., horns), the Committee was told that specific NuMI procedures have been written. Personnel, ranging from the main control room to the Fermilab Fire Department, received training and qualification related to the unique aspects of NuMI facilities and operation. Fermilab operation has already begun to provide spares for NuMI hardware, and the funds to support both NuMI and MINOS operation are factored into the operational budget. The areas of procedures, qualification of personnel, and transition to operations are adequately addressed for facility systems.

Complete Acceptance Testing and Correct Deficiencies

The project addressed this criterion in two manners. The Committee was presented with WBS sign-offs indicating the Level 2 Managers had completed and accepted their tasks and deliverables. Secondly, the project claims that the achievement of commissioning goals as identified in the Project Execution Plan satisfies this criterion. The Committee concurred with this assessment.

2. MINOS

Both the near and far MINOS detectors are operating well with nearly all detector channels working. The detectors performed as expected with both cosmic ray muons and neutrino interactions. The Level 2 Milestone for completion of the near detector was satisfied with the January 21, 2005 beam test. A suitable MINOS shift guide has been prepared.

All six commissioning goals for NuMI have been successfully met. The NuMI commissioning report clearly documents successful completion of each goal. All quantitative goals were exceeded by a fair margin.

3. Environment, Safety and Health

An Environmental Assessment (EA) was completed early in the project. The EA resulted in a Finding of No Significant Impact. Safety performance of the project improved throughout the life of the project. The SAD has been approved by the Fermi Site Office (FSO) and Fermilab, as well as the Accelerator Safety Envelop. FSO performed an independent review of the SAD, the Accelerator Safety Envelop, and the Shielding Assessment using FSO ES&H staff, Argonne Site Office staff, and Stanford Linear Accelerator Center staff. FSO participated as an observer in the Fermilab Accelerator Readiness Review.

4. Cost and Schedule

The NuMI budgeted Total Project Cost is \$171,368K. The project is near financial closeout. It is expected that approximately \$800K of Total Estimated Cost Funds and \$2.6 million of Other Project Costs will remain at closure. With the exception noted below, the project has been commissioned and is essentially complete as of February 2005, seven months ahead of the DOE baseline CD-4 milestone.

5. Open Item

One open item remains on the project: finalization of installation of a chiller for the target hall. Installation is scheduled to be complete by March 20, 2005, and will not impact overall transition to operations. The general prerequisites for CD-4 per DOE requirements have been met. The specific prerequisites (project checklist) have been met, and were verified and approved on February 17, 2005 (Attachment B).

CHARGE TO THE COMMITTEE

January 19, 2005

MEMORANDUM FOR DANIEL R. LEHMAN
DIRECTOR
CONSTRUCTION MANAGEMENT SUPPORT
DIVISION

FROM: ROBIN STAFFIN
ASSOCIATE DIRECTOR
OFFICE OF HIGH ENERGY PHYSICS

SUBJECT: NuMI CD-4 Review

I am requesting your office to perform an on-site review of the Neutrinos at the Main Injector (NuMI) project at Fermi National Accelerator Laboratory (Fermilab) on February 17, 2005. The purpose of the review is to judge the project's readiness to proceed to Critical Decision 4 (CD-4), Approve Start of Operations. General prerequisites for CD-4 are given in DOE M 413.3-1, Section 7.9.1. The review committee is asked to assess the status of the project with respect to both these general prerequisites and the attached NuMI project acceptance checklist, which was developed by the Project Director. Please provide a completed report of your review to me no later than March 18, 2005.

As you know, Phil Debenham, of this office, will serve as Executive Secretary to the review committee, consistent with his role as the program manager for this project. It is my understanding that you are working with him and members of the Fermilab staff to prepare for the review.

I wish to thank you in advance for agreeing to carry out this review. I look forward to receiving your committee's report.

Attachment:
NuMI Project Acceptance Checklist

cc:
J. Livengood, Fermi Site Office
R. Lutha, Fermi Site Office
S. Webster, Fermi Site Office
A. Byon-Wagner, SC-20
P. Debenham, SC-20
M. Procario, SC-20
D. Sutter, SC-20
L. Dever, SC-80
S. Tkaczyk, SC-81

NuMI Project Assessment Checklist**DOE M 413.3-1 Prerequisites for CD-4****Verify Performance Criteria Have Been Met**

Accomplished by documenting, in a NuMI Commissioning Report, achievement of the commissioning goals identified in the NuMI Project Execution Plan (PEP) (Table 3.1a). For each of the six parameters to be measured, the NuMI Commissioning Report states the commissioning goal, describes in detail how the parameter is measured to demonstrate achievement of the commissioning goal, and provides the result of the measurement. The document includes information on the calibration of key measurement devices and pictures and/or readout of the verifying measurements.

Issue a Final Safety Analysis Report

Met by approval of the Final Safety Analysis Report, as listed below.

Prepare Operating and Maintenance Procedures

NuMI operations and maintenance has been integrated into Fermilab wide procedures similar to all experimental operations. This has been documented in internal Fermilab memorandums.

Complete Acceptance Testing and Correct Deficiencies

Satisfied by achievement of the commissioning goals identified in the PEP, as documented in the NuMI Commissioning Report.

Complete Operations Readiness Review

Met by completion of the Accelerator Readiness Review, as listed below. This has been documented in Fermilab and Fermi Site Office memorandums.

Provide a Trained and Qualified Operations and Maintenance Staff

NuMI operations and maintenance performed by existing qualified staff. This has been documented in internal Fermilab memorandums.

Complete and Issue a Project Transition-to-Operations Report

Letter to the file documents that transition to operations has occurred. This letter report from the NuMI Project Manager to the Fermilab Director will document completion of the CD-4 commissioning goals, document Fermilab division ownership and acceptance of NuMI related facilities, and document the activities that remain to be completed for project closeout.

FNAL	DOE	Date
Accepting	Accepting	
Official	Official	

Safety Documentation

Safety Assessment Document	<u>Gary Burt</u>	<u>Stephen Keaton 2/17/05</u>
Shielding Assessment	<u>Gary Burt</u>	<u>Stephen Keaton 2/19/05</u>
Accelerator Readiness Review	<u>Gary Burt</u>	<u>Stephen Keaton 2/17/05</u>

FNAL	DOE	Date
Accepting	Accepting	
Official	Official	

Project Deliverables

A neutrino beam line in an underground enclosure at Fermilab, with sufficient radiation shielding to ensure compliance with applicable state and federal regulations when the beam line is operational.

	<u>Gary Burt</u>	<u>Stephen Keaton 2/17/05</u>
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A near detector for the MINOS experiment in an underground hall at Fermilab.

	<u>Gary Burt</u>	<u>Stephen Keaton 2/17/05</u>
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Two shafts to provide access to the underground facility at Fermilab, and a service building associated with each shaft.

	<u>Gary Burt</u>	<u>Stephen Keaton 2/17/05</u>
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A far MINOS detector comprising two supermodules, in an underground hall at the Soudan Underground Laboratory in Minnesota. The hall can accommodate either (a) three supermodules or (b) two supermodules and an emulsion detector.

	<u>Gary Burt</u>	<u>Stephen Keaton 2/17/05</u>
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Critical Decision 4
Approve Start of Operations
for the
Neutrinos at The Main Injector Project
at the
Fermi National Accelerator Laboratory
Office of High Energy Physics
Office of Science

Purpose

The purpose of this paper is to document the review by the Office of Science Energy Systems Acquisition Advisory Board-equivalent for Critical Decision 4 (CD-4), "Approve Start of Operations" for the Neutrinos at the Main Injector (NuMI) Project at the Fermi National Accelerator Laboratory (Fermilab).

Project Description

The NuMI Project provides for the construction of an intense, variable energy, beam of neutrinos using the Fermilab Main Injector, as well as large underground neutrino detectors located at Fermilab and Soudan, Minnesota. The purpose of the project is to enable a new generation of long baseline neutrino experiments that can decisively detect and accurately measure neutrino oscillations. Detection of such oscillations would firmly establish a non-zero value of neutrino mass. The scope of the NuMI Project includes the excavation of large underground laboratories to house the neutrino beam system and the Main Injector Neutrino Oscillation Search (MINOS) detectors. The project was initiated in FY1998 and has a Total Project Cost (TPC) of \$171M.

The technical commissioning goals of the project are:

- Proton intensity in the Target Hall of greater than 1×10^{12} 120 GeV protons per spill
- Proton direction established to within 1 mr of the known direction to the Far Detector in the Soudan Mine
- Neutrino beam energy of 2-4 GeV
- The majority of the 153 Near Detector planes sensitive to muons
- Observation of neutrinos in the Near Detector produced by the NuMI beam
- The majority of the 484 planes of the Far Detector sensitive to muons and atmospheric neutrinos

Critical Decision 4 Requirements

All requirements for CD-4 approval are completed:

- NuMI installation completed
- Final Safety Assessment Document/Accelerator Safety Envelope approved
- Accelerator Readiness Review completed
- NuMI Commissioning Report verified commissioning goals met
- SC/HEP Project Review recommended CD-4 approval

Project Completion

The scope of the project was to construct facilities at Fermilab in Batavia, Illinois and at the Soudan Underground Laboratory (SUL) in Soudan, Minnesota. The project includes the design and construction of a beam line and experimental facilities at the Fermilab site, two multi-purpose detectors for the MINOS experiment (a Near Detector at Fermilab and a Far Detector at SUL), and modifications of the SUL to accommodate the Far Detector.

The NuMI Project started in FY1998 and was completed in February 2005, seven months ahead of schedule. There are no remaining significant issues or corrections (technical, ES&H, etc.) that will impact the final TPC. The NuMI Project will be completed under the TPC of \$171M. The project cost will be finalized in the Project Closeout report, which will be issued in the summer of 2005.

All punch list items have been corrected by subcontractors and all equipment/systems meet design specifications. All specified field and factory testing have been completed and accepted by Fermilab.

Submitted by:

Stephen L. Webster
 Stephen L. Webster
 Federal Project Director
 Fermi Site Office

2/24/05
 Date

Joanna M. Livengood
 Joanna M. Livengood
 Acting Manager
 Fermi Site Office

2/24/05
 Date

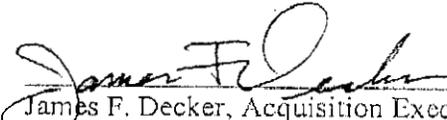
Phil Debenham
 Phil Debenham
 Program Manager
 Research and Technology Division
 Office of High Energy Physics

2.25.05
 Date

Robin Staffin
 Robin Staffin
 Associate Director
 Office of High Energy Physics

2/25/05
 Date

Approval of CD-4


James F. Decker, Acquisition Executive
Director
Office of Science

2/28/05
Date