Preliminary Project Execution Plan

for

The NOνA Project

at

Fermi National Accelerator Laboratory

March, 2007

NOvA Project
Preliminary Project Execution Plan (PEP)

Submitted by Integrated Project Team *(Submittal and Signatures required for final PEP)*

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Revision History		
Revision	Date	Reason
1	10/17/2005	This is the Project Execution Plan, required for Critical Decision-2. A preliminary version is required for CD-1.
2	4/1/2006	Added total cost table
3	7/11/2006	Updated change control thresholds
4	11-12/2006	Updated for: Fermilab contractor and IPT changes (added IPT Charter); acquisition strategy update; updated funding
5	01/16/2007	Incorporated Accelerator and NuMI Upgrades
6	3/5/2007	Revision of preliminary material for CD-1

NOνA Project
Preliminary Project Execution Plan
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1. Introduction

DOE approved a CD-0 Mission Need Statement for an Electron Neutrino Appearance experiment. The proposed NuMI Off-axis neutrino (ν) Appearance (NOvA) experiment has been selected to meet that mission need, utilizing the neutrino beam from the Neutrinos at the Main Injector (NUMI) facility at the Fermi National Accelerator Laboratory (Fermilab) site. The primary requirement to meet this mission need is a product of the proton intensity and mass of the far detector. The mission need statement described an alternative with a large detector and no upgrades to the NuMI beam. The currently preferred alternative combines a smaller detector with an upgraded NuMI beam. Given the importance of the planned increase in NUMI neutrino intensity to support the physics goals of NOvA, the importance of NOvA to the U.S. neutrino program, and in order to ensure appropriate project management, oversight and integration, this planned collection of accelerator and NUMI upgrades and improvements has been added to the scope of the project. The project will be referred to as NOvA hence forth.

The purpose of the NOνA project is to fabricate the NOνA near and far detectors in a state ready to take data and to provide a detector hall for the far detector, as well as upgrade the Fermilab Recycler and Main Injector accelerators and the NuMI beamline to support NOνA. The detector will permit the experimenters to study neutrino oscillations, in particular, to search for the oscillation of muon-type neutrinos to electron-type neutrinos. If these oscillations can be observed then the experimenters may be able to determine the mass-ordering of the neutrinos and to observe Charge Parity (CP) violation in the neutrino sector. Determination of the mass-ordering is a unique contribution made possible by NOνA's very long baseline.

1.1 Purpose and Context of This Document

This Preliminary Project Execution Plan summarizes the mission need and justification of the project, its objective and scope, the Department of Energy (DOE) management structure, the resource plan, and the environmental, safety, and health (ES&H) requirements. In addition it establishes the technical, cost, and schedule baseline ranges. Proposed DOE Baseline Change Control thresholds are also established in this document.

The project is being carried out by the Fermi Research Alliance, which will operate Fermi National Accelerator Laboratory (Fermilab) under a performance based contract with DOE. The NOνA Project Management Plan (PMP) describes the organization and systems that Fermilab will employ to manage the execution of the project and report to

DOE. The PMP also establishes the more detailed lower-tier milestones against which Fermilab and the DOE NOνA Project Director will measure project performance. The Project Execution Plan (PEP) will be the authoritative document. Should any conflicts be found between the PEP and the PMP, the PEP will be followed.

1.2 Approval and Revision

The PEP is approved by the Director, Office of Science, as a prerequisite of Critical Decision 2, Approval of Performance Baseline. Revisions to the PEP that are required to incorporate baseline change actions are considered to be approved by virtue of the corresponding baseline change.

The NOνA Project Management Plan is approved by the DOE NOνA Project Director.

2. Justification of Mission

As discussed in section 1, Introduction of this document, the Justification of Mission Need (CD-0) for an accelerator-based electron neutrino appearance experiment to measure neutrino mixing and to probe the neutrino mass hierarchy was approved in November 2005.

3. Project Description

The High Energy Physics program of the DOE Office of Science conducts basic research at Fermilab using the Main Injector to produce a high-intensity neutrino beam. Neutrinos have been demonstrated to oscillate from one type to another, though the oscillation of muon-type neutrinos to electron-type neutrinos has yet to be observed.

3.1 Scientific Objectives

The mission of the High Energy Physics (HEP) program is to explore and to discover the laws of nature as they apply to the basic constituents of matter, and the forces between them. The core of the mission centers on investigations of elementary particles and their interactions. A major component of the U.S. HEP program is the Fermi National Accelerator Laboratory (Fermilab). The NOνA experiment will use the NuMI facility at Fermilab to study neutrino oscillations to determine if muon-type neutrinos oscillate to electron-type neutrinos. The significance of the search for these oscillations is that, if they exist, we will ultimately be able to determine the mass ordering of the neutrino masses and determine if neutrino oscillations violate CP. There is good reason to believe that the very small neutrino masses are related to physics at an extremely high energy scale that cannot be studied directly with accelerator beams. There is also theoretical speculation that CP violation by neutrinos could be one of the key

ingredients necessary to understand why the Universe is composed solely of matter, rather than equal amounts of matter and antimatter.

NOνA has the most sensitivity to observe the oscillation of muon-type to electron-type neutrinos of any currently proposed experiment. NOνA also has the unique capability of having significant sensitivity for determining the mass-ordering.

3.2 Technical Goals

The general technical goals of the NOνA Project are presented below. The basic objective is to produce near and far detectors that can perform the state of the art study of neutrino oscillations outlined above, and to complete accelerator and beamline upgrades needed to support this. Further details on the detector systems can be found in the Conceptual Design Report for the NOνA Project and the NOνA proposal. The accelerator and beamline upgrades are covered in the Fermilab Proton Plan 2 Conceptual Design Report. A Technical Design Report will describe the design of the NOνA detector and the accelerator and beamline components comprising the NOνA project.

The NOνA Project

The sensitivity of NOνA depends on the product of the number of protons on target and the mass of the far detector. Based on the number of protons expected on the NuMI target in a 6-year run, the preliminary scope range includes a NOνA detector with a mass of approximately 20 kt. The hall that houses the NOνA Far Detector is being sized to accommodate this detector mass. The combination of protons on target and detector mass makes NOνA the most sensitive proposed experiment for all of the physics objectives listed above. The sensitivity can be increased even further for a given detector mass with a longer data run, or with more protons on target.

The NOνA detector must be capable of observing ν_μ to ν_e oscillations by observing the interaction of the ν_e in the active detector and identifying the associated electron. Electrons appear in the detector as "fuzzy" tracks due to the way the electromagnetic shower evolves in the low Z material from which the detector is constructed. The detector must further be able to distinguish electron tracks from muons and π^0's that appear as background. An additional background results from electron neutrinos that are produced from the decays of pions and kaons near the NuMI target rather than from ν_μ to ν_e oscillations that take place over a long baseline. The NOνA near detector will be used to measure the ν_e content of the beam off-axis near the NuMI target and extrapolate that background to the far detector.

To meet the scientific and technical objectives for the NOνA experiment a significant neutrino flux must be provided along with a detector of sufficient size and capability. The following performance parameters must be achieved:

- The Fermilab Recycler will be converted from an anti-proton to a proton storage ring, with a new injection line from the MI-8 proton line directly into the Recycler and a transfer line from the Recycler into the Main Injector. Six on six proton Booster batches must be slip-stacked in the Recycler, for a total intensity of 5×10^{13} protons/cycle, and then extracted to the Main Injector in a single turn, where they must be recaptured and accelerated. A 53 MHz RF system needs to be added in the Recycler for beam injection and slip-stacking. The Main Injector will have the slipping process offloaded to the Recycler, but the Main Injector cycle time must be reduced from 2.2 s to 1.333 s, which requires two additional RF stations. The NuMI neutrino line must accept a 75% increase in power, over its design value of 400 kW (to 700 kW), requiring improvements to the primary proton line to handle the faster repetition rate and new design for the target, plus upgrade of the present target pile air-cooling system, as well as reconfiguration of the target and focusing horn to change the energy spectrum of the neutrinos to a higher energy.
- The NOνA far detector hall must be constructed in an appropriate site in Northern Minnesota.
- The NOνA Far Detector must be constructed:
  - Plastic PVC extrusions must be manufactured to the appropriate size and shape. The inner walls of the extrusion cells must be highly reflective to maximize light collection.
  - The PVC extrusions must be glued together in alternating layers of vertical and horizontal extrusions into a strong, self-supporting honeycomb structure. The extrusions will be sealed at the ends, forming leak-tight containers that will hold liquid scintillator and wavelength shifting (WLS) fiber.
  - The light produced by the liquid scintillator and collected by the WLS fiber is directed onto a pixilated Avalanche Photo Diode (APD) optical detector. The output from the APD must be amplified, digitized and zero-suppressed by the front-end electronics.
  - A data acquisition system must accumulate the data from the front-end electronics and log the appropriate data to permanent storage.

4. Management Structure and Responsibilities

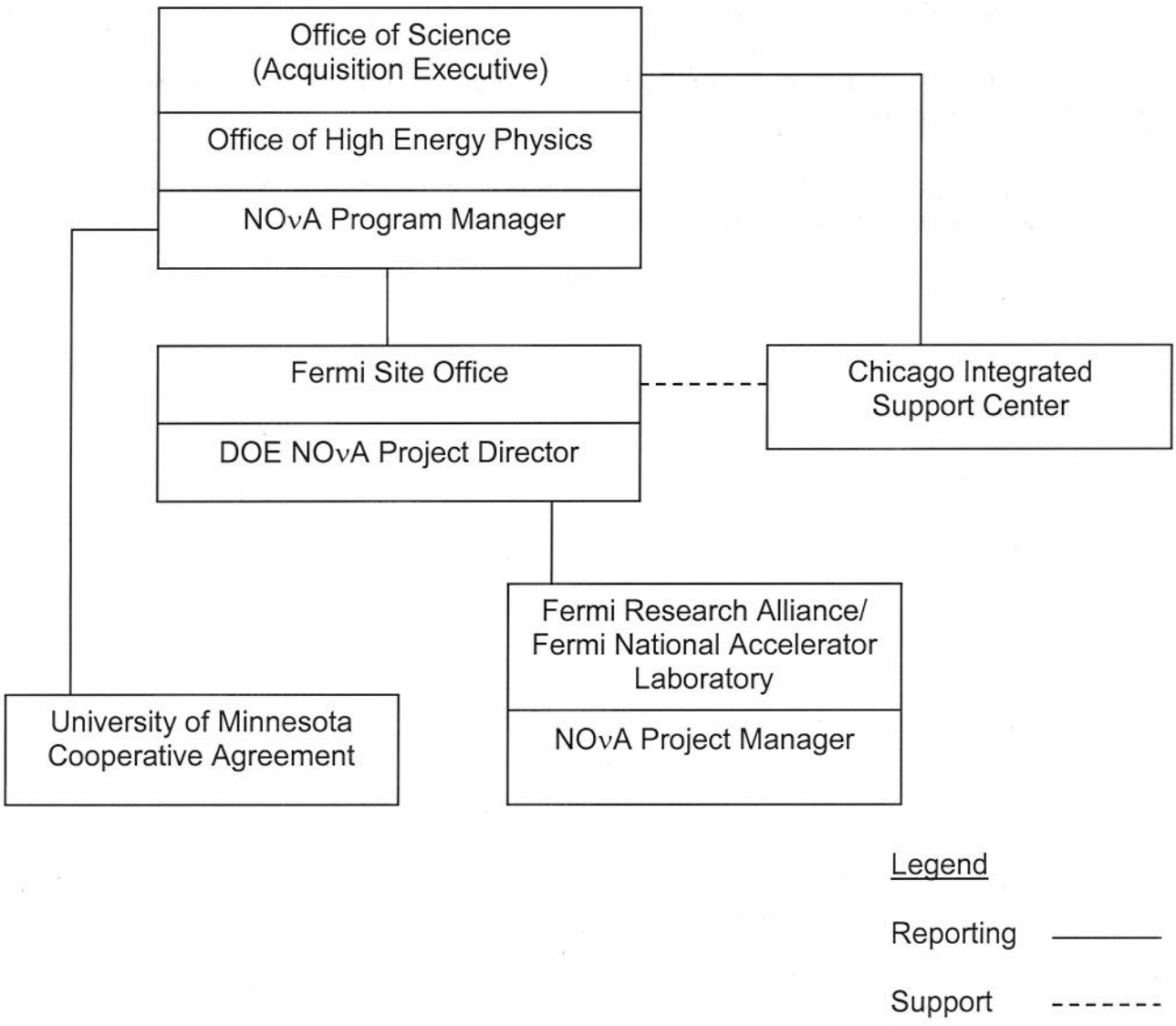
4.1 NOνA Integrated Project Team

The members of the NOνA Integrated Project Team (IPT) are drawn from the Fermi Site Office (FSO), Office of High Energy Physics (OHEP), and Fermilab. They have expertise in project management, engineering, procurement, environment, safety and health, particle physics, and other areas relevant to the NOνA project. It is necessary for this project to include contractor personnel on the IPT to achieve adequate technical expertise. Without the contractor personnel the particle physics expertise would then be limited to the OHEP program manager.

An IPT Charter is included as Appendix 1. As the project progresses, membership of the IPT will change as needed.

The DOE organization for the NOνA Project is shown in Figure 4.1. Each of the major organizational elements is discussed below the figure.

Figure 4.1
NOνA Project Office
Project Management Organization



4.2 Office of High Energy Physics

Within the Office of Science, the Office of High Energy Physics has overall DOE responsibility for the development of High Energy Physics (HEP). The Director of the Office of Science will serve as the Acquisition Executive for this project. The Office of High Energy Physics (OHEP) is the lead program organization for the NOνA Project. The prime headquarters point of contact for the project will be the NOνA Program Manager, an OHEP employee who is appointed by the Associate Director of the OHEP.

The responsibilities of OHEP relating to the project include the following:

- Participate and concur in annual budget process;
- Review the PEP and substantive changes to it;
- Review the initial cost, schedule, and technical baselines;
- Perform project management reviews on a roughly semiannual basis;
- Ensure that funding is provided on a timely basis;
- Coordinate project needs within DOE headquarters; and
- Coordinate with the DOE NOνA Project Director.

4.3 SC Integrated Support Center and Fermi Site Office

The Office of Science Integrated Support Center provides support to the Fermi Site Office (FSO), e.g., in the areas of legal, ES&H, and procurement. FSO is the responsible DOE office on site at Fermilab that administers the contract and provides day-to-day DOE oversight of the laboratory. The FSO Manager has assigned the DOE NOνA Project Director the authority for day-to-day implementation and direction of the project. The FSO Manager will provide the DOE NOνA Project Director with support from FSO staff when appropriate.

4.4 DOE NOνA Project Director

The management responsibility, authority, and accountability for execution of the project have been assigned to the DOE NOνA Project Director. The DOE NOνA Project Director is a DOE employee who is appointed by the FSO Manager, subject to the approval of the Director of the Office of Science. The DOE NOνA Project Director receives guidance and direction from the OHEP and serves as the principal point of contact for DOE headquarters on issues specific to the project.

Specific responsibilities of the DOE NOνA Project Director are:

- Serve as Integrated Project Team lead in drafting/coordinating the Acquisition Strategy and PEP;

- Review and approve the Project Management Plan and subsequent revisions;
- Implement procedures for baseline management and control, approve baseline changes at Level 2 and recommend changes or corrective action to baselines above Level 2;
- Maintain close contact with the activities of Fermilab to assure that the goals and schedules are met in a timely and effective manner. Review project performance monthly and keep the OHEP informed of cost, schedule, and technical progress and problems in a timely manner;
- Coordinate with the FSO Manager regarding approval of subcontract procurement actions performed by Fermilab;
- Oversee the preparation and review of the safety assessment documents;
- Direct the updating of the Project Execution Plan and the Project Management Plan;
- Coordinate updates of the budget;
- Participate in and provide support for the program peer reviews, reviews by oversight committees and validation of the project;
- Submit quarterly reports and other reports on the status of the project for DOE management as required in this Project Execution Plan and applicable DOE requirements;
- Aid in the compliance by the NOνA Project with appropriate DOE requirements, and contracting regulations.

4.5 DOE NOνA Deputy Project Director

The DOE NOνA Deputy Project Director reports to the DOE NOνA Project Director and represents the NOνA Project in all functions stated above when the Project Director is not available. The Project Director may delegate specific duties to the deputy.

4.6 Fermi National Accelerator Laboratory

The Fermi Research Alliance, LLC. (FRA) manages and operates Fermilab for DOE under the terms and conditions of Contract No. DE-AC02-07CH11359. FRA has provided the Laboratory Director with the overall responsibility for all projects, programs, operations, and facilities at Fermilab. Fermilab will have the responsibility of completing the NOνA Project within the technical, schedule, and cost baselines defined in the PEP.

The NOνA Project Office performs management and oversight of the NOνA Project. The head of the Project Office is the NOνA Project Manager. The NOνA Project Manager provides oversight, coordination, management, and direction of the NOνA Project. The NOνA Project Manager has the responsibility and authority for delivering

the project scope on schedule and within budget. The Project Manager has the day-to-day responsibility for managing the Project Office. The NOνA Project Manager is appointed by the Director of Fermilab, with the concurrence of the NOνA collaboration, and reports to him/her. Other details of the roles and responsibilities of the NOνA Project Manager can be found in the NOνA Project Management Plan (PMP).

The NOνA Deputy Project Manager reports to the NOνA Project Manager and represents the NOνA Project in all functions when the Project Manager is not available, including budget authority. The Project Manager may delegate specific duties to the deputy. The Deputy PM is appointed by the PM with the concurrence of the NOνA collaboration and the Fermilab Director.

The NOνA Associate Project Manager reports to the NOνA Project Manager. The Project Manager may delegate specific duties to the associate. The Associate PM is appointed by the PM with the concurrence of the NOνA collaboration and the Fermilab Director. Fermilab's organization for the NOνA Project is shown in figure 4.2.

Fermilab has developed procedures to support the project office in its work and to ensure good coordination between the project and the rest of the lab. In the Fermilab Directorate is the Office of Project Management Oversight (OPMO) whose purpose is to increase the visibility of and the attention paid to large projects and to ensure their completion on-time and within budget while delivering the agreed upon scope. The role and functions of the OPMO include: providing assistance in the planning, preparation, execution, monitoring, review, assessment, and management of large projects within the laboratory. The OPMO reports to the Deputy Director of Fermilab.

The Fermilab Director has delegated to the Associate Director for Research the direct laboratory oversight and management of the NOνA Project. He/she is assisted in this responsibility and advised by the Associate Director for Accelerators, who holds primary responsibility for oversight of the construction and modification of accelerator facilities within the NOνA Project. The Associate Director for Research of Fermilab chairs the NOνA Project Management Group (PMG) that meets as required to monitor the progress of the project, and the Associate Director for Accelerators serves as deputy chair of the PMG. The primary task of the PMG is to provide coordination between the project and the rest of the lab. The group normally consists of the NOνA Spokesperson, the NOνA Project Manager, Deputy and Associate, and the Heads of participating Divisions and Sections, Laboratory Management personnel, and other representatives of Fermilab and NOνA. Any conflicts between the project and the rest of the lab are identified and resolved through the PMG. These can include resolving schedule conflicts and setting priorities on the use of skilled manpower.

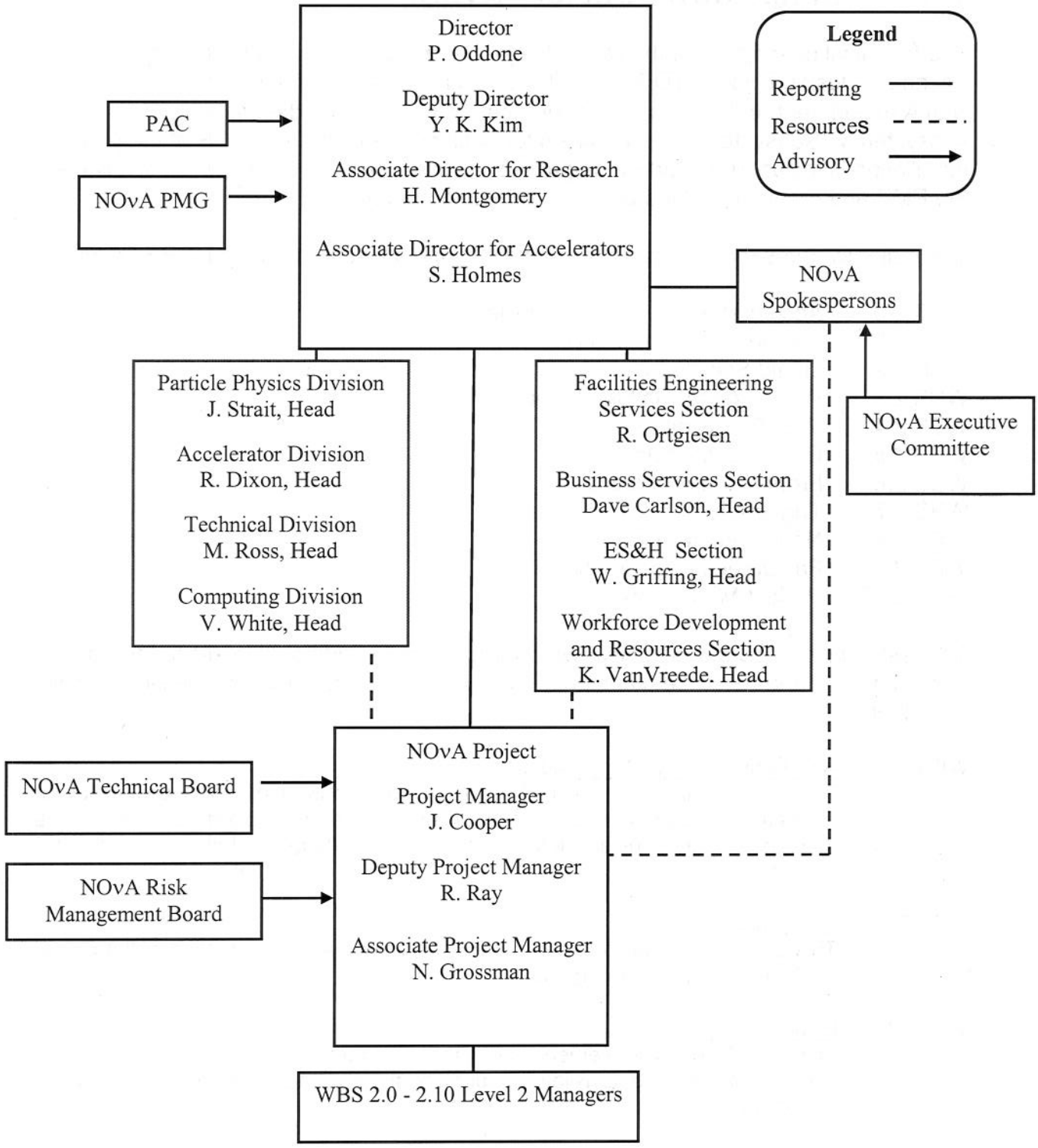
The NOνA PMP parallels the DOE PEP. It documents Fermilab's plan for carrying out the project. It has lower level details such as level 2 and lower milestones, the detailed procedures for running the project, and it describes the roles and responsibilities of the NOνA Project Manager, Fermilab, the funding agencies, advisory groups and the NOνA collaboration.

4.7 University of Minnesota

The University of Minnesota has submitted an unsolicited proposal for a Cooperative Agreement with the DOE to support collaborative research and development in Neutrino Physics, including work on the NOνA Project. For the NOνA Project, the University proposes to acquire land, prepare the site and construct the access road and building required for the far detector laboratory in Northern Minnesota. The University expects to coordinate all of the work with the DOE and Fermilab NOνA Project Management, with periodic agreement on detailing tasks to be completed, and on schedules and funding for each task with periodic reports on progress. The University will support development of baseline task funding and schedules that will support Critical Decision 2 (CD-2) for the NOνA Project. The proposal describes how the Cooperative Agreement fits into the NOνA Project Management structure, and a further Memorandum of Understanding, management plan, or other equivalent means for establishing the working and project relationships and requirements is planned prior to CD-2.

Figure 4.2

Management relationships between the project, lab, and collaboration.



5. Work Breakdown Structure (WBS)

The technical description of the NOνA Project is presented in the NOνA Project Technical Design Report (TDR). The TDR describes the principal components of the NOνA experiment and serves as a reference for the following descriptions of subsystems. Subsystems are the basis for defining the high-level WBS of the project. Installation is included as part of the project. Further details of the WBS are available in the PMP and resource-loaded cost and schedule materials.

The major systems that comprise the Project scope are represented at WBS Level 2.

WBS 2.0	Accelerator and NuMI Upgrades
WBS 2.1	Far Detector Site and Building
WBS 2.2	Liquid Scintillator
WBS 2.3	Wave Length Shifting Fiber
WBS 2.4	PVC Extrusions
WBS 2.5	Extrusion Modules
WBS 2.6	Front-End Electronics
WBS 2.7	Trigger/DAQ
WBS 2.8	Near Detector Assembly
WBS 2.9	Far Detector Assembly
WBS 2.10	Project Management

The task-based WBS extends downward through many additional levels to facilitate cost, schedule and resource planning. The WBS Level 2 structure for the Detector is described below.

WBS 2.0 Accelerator and NuMI Upgrades

This level 2 summary element includes the procurement, QA, construction and installation of components necessary for accelerator improvements in the Main Injector and Recycler accelerators, and beamline/target hall improvements at the NuMI facility.

WBS 2.1 Site and Building

This Level 2 summary element covers the design and construction of the Site and far Detector Enclosure and Building.

WBS 2.2 Liquid Scintillator

This level 2 summary element covers the procurement, production, QA and shipping of the liquid scintillator required by the project for both the Near and Far Detectors.

WBS 2.3 Wavelength Shifting Fiber
This level 2 summary element covers the procurement, QA and shipping of wavelength shifting fiber.

WBS 2.4 PVC Extrusions
This level 2 summary element covers the procurement, QA and shipping of the PVC extrusions.

WBS 2.5 PVC Modules
This level 2 summary element provides for construction and QA of the PVC modules for both the Near and Far Detectors and shipping of the completed and tested modules to their respective detector sites.

WBS 2.6 Electronics Production
This level 2 summary element includes the Avalanche Photo Diode (APD) optical sensors, the thermo-electric (TE) coolers for the APDs, the custom ASIC that amplifies and multiplexes the APD signals, the ADC that digitizes the signals and the FPGAs that zero suppress and time-stamps the data. Also included is the low-voltage system for the TE coolers and the front-end electronics, the high voltage system for the APDs and a cooling system to remove the heat from the TE coolers. These systems will be provided for both the Near and Far Detectors.

WBS 2.7 Data Acquisition System
This level 2 summary element includes the hardware and software to record the data to archival storage and to control and monitor both the Near and Far Detectors. It includes the fiber, cable, switches and memory necessary to move and buffer the data, a PC farm for online filtering, local disk storage, a system for moving data to permanent storage at Fermilab, software and testing.

WBS 2.8 Near Detector Assembly
This level 2 summary element provides for the engineering design of the mechanical devices and tooling needed to install the NOνA Near Detector. Fabrication of the necessary tooling, installation and commissioning of the near Detector in its underground location at Fermilab is also included.

WBS 2.9 Far Detector Assembly
This level 2 summary element provides for the engineering design of the mechanical systems and tooling needed to install the NOνA Far Detector. Fabrication of the necessary tooling, installation and commissioning of the detector in the detector building in Northern Minnesota is also included.

WBS 2.10 Project Management
This Level 2 summary element consists of reviews, reports, site visits, local supervision, running technical board meetings, standards preparation, tracking and analysis, schedule preparation tracking and analysis, change control. It also

includes procurement of relevant software and computers, the cost of running the project office and the salaries of non-scientists working on the project.

6. Resource Plan

NOνA will be dominantly funded by the Department of Energy as an MIE. The estimated resources from the DOE are listed below.

Table 6.1
Estimated Funding (AY $M)

Year	NOvA Total
2007	8.3
2008	36.0
2009	70.0
2010	69.0
2011	46.0
2012	28.0
2013	2.7
Total	**260**

7. Project Baselines and Control Levels

The project baselines and control levels are defined in a hierarchical manner that provides change control authority at the appropriate management level. The highest level of baseline change control authority is defined as Level 0. Changes at Level 0 are approved by the DOE Deputy Secretary. Changes below Level 0 are approved as follows:

- Level 1: Acquisition Executive (Director, Office of Science);
- Level 2: DOE NOνA Project Director;
- Level 3: Fermilab as specified in the NOνA PMP.

Change control thresholds for the project are presented in section 7.1. The technical, cost, and schedule baselines and the associated control levels down to Level 2 are presented in sections 7.2, 7.3, and 7.4.

7.1 Baseline Change Control

The NOνA detector is unique in that four items, two of which are linked to the volatile cost of crude oil, dominate the cost. The Far Detector Hall, the PVC extrusions, the liquid scintillator and the wavelength shifting fiber constitute approximately 70% of the total detector related costs, in the preliminary estimate. At this level, small per unit cost changes on these items could easily trip change control thresholds. The change control thresholds are presented in Table 7.1.

Table 7.1 NOνA Project Technical, Schedule, and Cost Baseline Control Levels*

	Secretarial Acquisition Executive (Level 0)	Acquisition Executive (Level 1)	DOE NOνA Project Director (Level 2)
Technical	Any change in scope and/or performance that affects mission need requirements.	Addition or deletion of any major subsystem that does not affect mission need requirements.	
Schedule	6 month or greater increase (cumulative) in the original project completion date.	Any change to level 1 milestones of > six months.	Any change to level 2 milestones (see PMP).
Cost	Increase in excess of $25M or 25% (cumulative) of the original cost baseline.	Any increase in Total Project Cost.	Any cumulative use of contingency in excess of $500k.

*Changes must be recommended at all applicable lower levels prior to being forwarded to the next higher level for consideration.

7.2 Technical Baseline

The project comprises completing the subsystems outlined in the NOνA Project WBS described in Section 5. Also included is post-installation acceptance testing of the detectors, defined as commissioning with pulsers, calibration systems and cosmic rays. The technical definition of project completion for the NOνA Project is listed in Table 7.2.

Table 7.2

CD-4, Project Closeout Definition

Subsystem	Technical Definition of Completion
2.0 Accelerator & NuMI Upgrades	All accelerator and NuMI upgrades and modifications installed and ready for initial operation. All safety approvals necessary for operation completed.
2.1 Far Site and Building	All building and electrical work complete as specified and final acceptance issued for all construction and outfitting contracts.
2.2 Liquid Scintillator	The contracted amount of liquid scintillator has been delivered and passed QA inspection at the far detector site.
2.3 Wavelength Shifting Fiber	The contracted amount of WLS fiber has been delivered and passed QA inspection.
2.4 PVC Extrusions	The contracted amount of PVC extrusions have been delivered and passed QA inspection.
2.5 PVC Modules	The required number of modules have been assembled and passed QA inspection at the factory sites and have been delivered to the far detector site.
2.6 Front-end Electronics	The required number of boards have been assembled, tested and installed on the near and far detectors.
2.7 Trigger/DAQ	Readout of all detectors and observation of cosmic rays.
2.8 Near Detector Assembly	Final near detector planes have been glued into place and filled with liquid scintillator.
2.9 Far Detector Assembly	Final far detector planes have been glued into place and filled with liquid scintillator.
2.10 Project Management	All other WBS items are complete and the detector has been successfully commissioned with cosmic rays, each 5 kt segment of the Far Detector has observed a neutrino charged current event within the NuMI beam spill and the Near Detector has observed a neutrino charged current event within the NuMI beam spill.

7.3 Cost Estimate

Table 7.3 below presents the estimated costs for the NOνA Project for up to a 20 kt detector, consistent with the preliminary CD-1 range. Baseline costs are calculated from bottoms-up cost estimates. Level 3 project managers estimate contingency by applying project wide contingency rules to the details of individual tasks in the work breakdown structure. Comparison with the funding profile in Table 6.1 indicates a mismatch that will be addressed prior to CD-2. NOνA estimates that an 18 kt detector can be built within the constraints of the profile in Table 6.1. It is anticipated that the best case earned contingency scenario would allow a modest upscope to a 20 kt detector, which would fill the far detector building. The Project is actively working on completing the baseline cost estimate for CD-2, including incorporating results of on-going cost reduction and value engineering efforts.

Table 7.3 NOνA Project
Preliminary Project Cost Breakdown (AY$ in Millions)

NOvA Project Cost Breakdown by WBS element at Level 2					
PPEP table 7.3					
AY$M					
WBS		Item	TEC	OPC	TPC
2.0		Accelerator & NuMI Upgrades	44.3	14.3	**58.6**
2.1		Far Detector Site & Building	0.4	48.1	**48.5**
2.2		Liquid Scintillator	35.0	0.5	**35.5**
2.3		WLS Fiber	19.4	0.1	**19.6**
2.4		PVC Extrusions	40.5	0.9	**41.4**
2.5		PVC Modules	14.0	1.2	**15.2**
2.6		Electonics	18.5	2.4	**20.9**
2.7		Data Acquisition	3.7	1.7	**5.4**
2.8		Near Detector Assembly	1.9	0.7	**2.6**
2.9		Far Detector Assembly	22.7	0.7	**23.4**
2.10		Project Management	5.6	0.6	**6.2**
		Subtotal	**206.1**	**71.2**	277.3

7.4 Schedule Baseline

Table 7.4a below presents the preliminary schedule baselines for the NOνA Project. The later critical decision dates may be further revised as the performance baseline is finalized, prior to critical decision 2. There is one milestone that will be held by the Secretarial Acquisition Executive.

NOνA uses a system of "tiered" milestones. Milestones are established during the development of the resource-loaded cost and schedule. These are reviewed by the Fermilab NOνA Project Manager who selects a subset, called Level 3 milestones to be monitored jointly by the NOνA Project Manager and Fermilab management. From these, a smaller number, called Level 2 milestones are selected to be monitored and controlled by the DOE NOνA Project Director. From those, a smaller number of Level 1 milestones are selected to be monitored and controlled by the Office of Science Acquisition Executive (i.e. for a change > six months).

At each level, milestones are chosen from the lower level based on the following criteria: significance in judging the progress of the project; relatively uniform distribution throughout the lifetime of the project; proximity to the critical path; and distribution across the WBS Level 2 subprojects. The Level 1 milestones of the NOνA Project, shown in Table 7.4b, meet these criteria.

Table 7.4a
NOνA Critical Decisions

Description	Date
CD-0: Approve Mission Need	November 2005
CD-1: Approve Alternative Selection and Cost Range	2nd Quarter FY 07
CD-2/3A: Approve Performance Baseline/ Project Start (access road + procurements)	4th Quarter FY07
CD-3B: Approve Start of Construction	2nd Quarter FY08
CD-4: Approve Start of Operations or Project Closeout (Level 0 Milestone)	4th Quarter FY13

Table 7.4b
Level 1 Milestones for the NOνA Project

No.	Description	Date
1.1	Beneficial occupancy of far building	2nd Quarter FY 11
1.2	Near detector operational	2nd Quarter FY 12
1.3	Full far detector complete	2nd Quarter FY 13

CD-3A is to approve construction of a site access road that is needed to support start of construction for the far detector building. An earlier start in the road construction will enable a schedule gain. In addition, CD-3A is to approve start of procurements for key detector materials such as fiber and Avalanche Photo Diodes as well as start procurement and fabrication of many accelerator and NuMI components and upgrades.

If the project is able to realize contingency savings, then additional mass will be added to the detector, requiring additional time to complete, up until the proposed CD-4 date.

8. Acquisition Strategy

An Acquisition Strategy (AS) approved by the Acquisition Executive (AE) and reviewed by the DOE Science Office of Project Assessment (OPA) is a prerequisite for CD-1. An AS for the NOνA project has been completed and submitted to OPA for review and approval by the AE. Briefly, the AS describes why FRA has been chosen to lead the project based on the need to deeply involve the collaborating physicists to participate in the design and construction, and to simplify the interfaces of the project to the rest of the lab. Much of the work will be done by collaborating institutions under fixed price contracts from Fermilab. As discussed in the Acquisition Strategy, the DOE has received an unsolicited proposal from the University of Minnesota to conduct research on neutrino oscillations as part of the NOvA collaboration. As part of the research program the University proposes to construct the far detector enclosure on university owned land, to operate the building on this site, to be responsible for security and ES&H on the site, and to participate in the calibrations, data-taking, and maintenance of the NOvA detector and the subsequent data analysis. The University of Minnesota currently operates the Soudan Underground Laboratory (SUL) in Northern Minnestoa and successfully managed the construction the cavern in the SUL that now houses the MINOS detector, and so it has relevant experience.

This financial assistance award would include both a portion of the NOνA TPC (for construction of the detector enclosure) and subsequent research activities. The OHEP, supported by the DOE NOνA project staff at the Fermi Site Office, will provide oversight for both the cooperative agreement and the detector fabrication funded as a Major Item of Equipment (MIE) and interactions between the two efforts. Upon DOE acceptance of the Cooperative Agreement and prior to CD-2, negotiation is planned between Fermilab/NOνA Project and the awardee to define authorities among the parties, and agree upon means to ensure adequate communications, work authorizations and flow, and project controls and reporting to cover design, construction and oversight activities. A Memorandum of Understanding, management plan, or other equivalent means for establishing the working and project relationship and requirements is anticipated.

9. Project Monitoring and Reporting

The DOE NOνA Project Director will provide quarterly reports on the NOνA Project to the Office of Science and monthly updates to the Project Assessment and Reporting System (PARS). Monitoring of the NOνA Project will occur through established mechanisms among project participants. Reviews of the project status will be conducted by the Associate Director of High Energy Physics approximately semiannually. Fermilab will provide formal project monthly reports to the DOE NOνA Project Director. The requirements of the monthly reports will be included in the NOνA Project PMP.

Reviews will be conducted to assist in the elimination of problems; to verify that interfaces between activities and tasks are acceptable; and to verify that the project is progressing satisfactorily.

10. Environment Safety and Health

10.1 National Environmental Policy Act (NEPA)

An Environmental Assessment (EA) under NEPA is required for NOνA to cover the activities at Fermilab as well as the activities in the State of Minnesota. An EA is being prepared to evaluate the potential environmental impacts associated with the full NOνA Project, including proposed construction or upgrade and operation of facilities for NOνA at Fermilab and its far detector facility located in Ash River, Minnesota. The work on the Fermilab site that is covered includes the construction and operation of the accelerator and NuMI beamline upgrades, the construction and operation of the NOνA near Detector Integration Prototype in the MINOS surface building, the construction and operation of the Near Detector in the underground MINOS access tunnel at Fermilab and the operation of a scintillator blending facility at Fermilab. The EA will incorporate an extensive radiological assessment of increasing the power of the NuMI beam line.

Specific characterization has also been conducted of the environment of the preferred site for the far detector, to evaluate potential environmental impacts of the proposed project in northern Minnesota. Although not required, the University of Minnesota may utilize this information to prepare a discretionary Environmental Assessment Worksheet (EAW) for State review in accordance with the State of Minnesota environmental review process. If the University does so, the federal EA may incorporate the Minnesota EAW by reference. If the University does not prepare a voluntary EAW, the information will be incorporated into the EA.

An EA for the NOνA Project has been drafted, with the information for the Minnesota

activities appended as a draft EAW, and has been submitted for DOE review. The EA draft is being finalized based on the initial DOE review, and in preparation for submittal to the States (Illinois, Wisconsin and Minnesota) and for a public comment period. State and public comments will be reviewed and a complete EA incorporating final revisions is anticipated in Spring 2007. The NEPA process and the final decision document is expected in Summer 2007 to support a CD-2 approval.

10.2 Preliminary Safety Assessment Document

A NOνA Hazard Assessment Document has been prepared for NOνA and, after approval, will serve as the basis for the Preliminary Safety Assessment Document (PSAD) required for CD-2. A Safety Assessment Document (SAD) will be prepared and approved prior to sustained operations of the completed NOνA Detector. Updates to the existing Accelerator Division (AD) SAD and the NuMI/MINOS SAD will be prepared and approved prior to commissioning the accelerator and NuMI Beamline systems upgraded in the NOνA Project.

10.3 Integrated Safety Management

NOνA Project activities are carried out at, or under the supervision of national laboratories and institutions and are subject to the Environmental, Safety, and Health (ES&H) policies and procedures of those specific laboratories or institutions. The DOE national laboratories participating in the NOνA Project (Fermilab and Argonne National Laboratory) have DOE-approved Integrated Safety Management (ISM) Systems, which provide a framework for all work conducted at each laboratory. NOνA Project work at Fermilab and Argonne is fully subject to the local DOE line ES&H management oversight and operational awareness mechanisms. Laboratory Divisions and Sections (D/S's) and the project team work together to assure effective implementation of the ISM system. Laboratory D/S's provide line management support for NOνA Project work carried out within the Laboratory D/S, along with the D/S support from safety committees and ES&H staff that provide advice, oversight and ES&H approvals as required to support project work. Work at Universities is fully subject to OSHA and applicable state and federal external regulation and enforcement.

11. Technical Considerations

11.1 Value Management

Value Management (VM) principles are essential to proper program management and have been incorporated at the early design and development stages of the technical

requirements. These principles will also be employed as the cost and schedule parameters mature over time. Use of the VM approach provides a systematic framework to analyze the functions of systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required performance, quality, reliability and safety. VM elements have been incorporated as a part of each of the technical and program reviews to date.

Value Management (VM) is a process by which costs can be reduced through an analysis of a products function, without sacrificing its performance and quality. The focus on a reduced cost, enhanced value relationship, determined through a functional analysis is integral to the design process for large scientific projects. The process for the detector itself is done in a different fashion than is generally employed in an industrial or construction setting. The NOνA Project and Fermilab are committed to VM principles in the design, construction and installation of the experiment, its associated infrastructure and the accelerator and NuMI upgrades. VM is accomplished in the NOνA Project through an extensive design review process which each subproject and component is subject to before beginning construction. This peer review process takes place in external reviews conducted by the Fermilab and the Department of Energy, and in internal reviews to determine baseline costs, technical adequacy, and production readiness. Systems are designed to ensure that the components of the accelerator, beamline and detector meet the design specifications and operate within the parameters mandated by the requirements of the High Energy Physics Program. Value Management in the NOνA Project is discussed in more detail in the PMP under Quality Management Program.

11.2 Configuration Management

A Configuration Management Program (CMP) will be implemented that will describe the configuration management (CM) responsibilities and processes that support the design and implementation of the NOνA Project. The purpose of this CMP is to identify the organization providing the configuration control, define what a configuration-controlled item is, describe the change control process, and identify the plan for configuration status accounting and verification. The CMP is designed to ensure that:

- baselines are defined and documented;
- documentation is identified, released and controlled;
- changes to the baseline are evaluated and controlled;
- approved configuration changes are implemented and tracked; and
- configuration status accounting is accomplished.

Systems and components specific to the NOνA Project will be reviewed in accordance with the principles provided in ANSI/EIA-649-1998, *National Consensus Standard for*

Configuration Management. The degree of rigor employed will be tailored, based on the functions and importance of each system or component.

11.3 Quality Assurance

Quality Assurance is an integral part of the design, fabrication and construction of the NOνA Project. Special attention is paid to items that are most critical to the schedule and performance requirements of the project. All work performed at Fermilab will draw on the guidelines and criteria set out in Fermilab Director's Policy Manual, document #10.000. Quality Assurance will include:

- management criteria related to organizational structure, responsibilities, planning, scheduling, and cost control;
- training and qualifications of personnel;
- quality improvement;
- documentation and records;
- work processes;
- engineering and design;
- procurement;
- inspection and acceptance testing; and
- assessment.

Achieving a quality end product is a line responsibility that extends from the bottom of the Organizational Breakdown Structure (OBS) to the top. All levels of personnel in the project are encouraged to report performance problems and to encourage others to report problems as they are discovered. Stop Work Authority related to quality of work is given to all managers and supervisory personnel within the project. They are authorized and expected to halt unsatisfactory work being performed by any of the individuals or organizations reporting to them. The relevant Division Head or the Project Manager may specify other stop work authority outside of the normal management chain at their discretion.

The objective is to identify problems related to quality early in the process at a time when cost effective, timely corrections can be implemented easily. The project will hold regular meetings at which Level 2 and Level 3 managers will report on the status and problems of their subprojects. Corrective actions will be taken, using the appropriate and well defined level of change control, to solve these problems. These are normal, well understood project management techniques that have been used successfully in HEP projects many times in the past.

11.4 Safeguards and Securities Plan & Vulnerability Assessment

Security issues were identified early in the NOνA Project along with considering procedures for mitigating any concerns. The potential security threats to the NOνA project are conventional theft and vandalism. Security of computing networks will also be required. The NOνA Project will create no new security issues during design or fabrication. NOνA has no special nuclear material (enriched uranium or plutonium) and no nuclear material (natural or depleted uranium). Thus extra protective measures in these areas are not required.

The NOνA project is most vulnerable at the Far Detector site since that site does not fall within a highly protected area like a national laboratory or a university campus. The Cooperative Agreement recipient shall have the primary responsibility for implementation of security at the Far Detector site. Providing adequate security at a remote location adds to the project cost and has been accounted for in the NOνA cost estimate. The required security measures will be spelled out in detail in the Cooperative Agreement.

Safeguards and security for project activities at the Fermilab site will be covered under Fermilab's existing DOE-approved program. No laboratory safeguards and security requirements will need to be changed for installation or operations subsequent to project completion. Access to Fermilab is controlled to ensure worker and public safety and property protection. None of the work at Fermilab or on the NOνA Project is classified. The risk of safeguards and security issues is, therefore, small. NOνA is not an attractive target for terrorists, theft, or malicious action. Therefore, due to the 24/7 security force on site, Fermilab's safeguards and security program, and the non-attractiveness of NOνA as a target, the vulnerability assessment is very low.

Appropriate security will be built into the NOνA computer Data Acquisition system as a requirement. As this is currently a rapidly changing and timely field with the onset of grid computing, the project will defer as long as practical before committing to a particular protocol to ensure maximal technical benefit based on available state-of the-art technology and to meet existing security requirements at the time. The project will follow the Fermilab Computing Division's lead on this issue and will be included within Fermilab's online security envelope.

12. Risk Management

Every effort has been made to specify the project in a manner that reduces the level of risk to an acceptably low level.

The IPT expects the project to manage risk as a line responsibility. Risks are identified by WBS Level 2 managers and ranked within their projects based on probability of occurrence and impact/consequence. NOvA Project management reviews the results and classifies the risks as high, medium, or low based on a "Risk Classification Matrix." Included in this process are high level risks and risks that might be shared among several subprojects that may be identified and "owned" by the Project Manager.

The Level 2 managers then develop Risk Mitigation/Abatement Plans for all risks rated as either high or moderate. Risk information will be included in a database. The Project Manager will establish and maintain a "watch-list" of risk issues and events that need special attention or on which action is imminent. Risk Management issues will be regularly addressed at NOvA Technical Board meetings and will be included in monthly reports.

Use of fixed-price subcontracts and competition will be maximized to reduce cost risk.

Schedule risk will be minimized via:

- Realistic planning;
- Verification of subcontractor's credit and capacity during evaluation;
- Close surveillance of subcontractor performance;
- Advance expediting; and
- Incremental awards to multiple subcontractors for the same item when necessary to assure total quantity or required delivery.

Incentive subcontracts, such as fixed-price with incentive, will be considered when a reasonably firm basis for pricing does not exist or the nature of the requirement is such that the subcontractor's assumption of a degree of cost risk will provide a positive profit incentive for effective cost and/or schedule control and performance.

Appendix 1.

Integrated Project Team Charter

Mission

The mission of the NOνA Integrated Project Team (IPT) is to provide for planning, coordination and communication for the NOνA Project that will ensure project completion on schedule, within budget and fully capable of meeting NOνA's technical and scientific goals while complying with all applicable laws and standards for environment, safety and health. The IPT will also ensure that project management is carried out with integrity and that quality assurance principles are applied to processes within the project.

Purpose and Goals

1. Support the Federal Project Director and NOνA Project Manager in performance of project management responsibilities.
2. Develop and implement an appropriate project contracting and acquisition strategy.
3. Assure all project interfaces are identified, completely described/defined, and managed to completion.
4. Identify and define appropriate and adequate project performance parameters.
5. Perform periodic reviews and assessments of project performance and status against established performance parameters, baselines, milestones, and deliverables, taking corrective actions as appropriate.
6. As necessary, plan and participate in project reviews, audits, and appraisals.
7. Support development of all Critical Decision (CD) packages.
8. Review and comment on project deliverables, e.g. drawings, specifications, procurement and construction packages.
9. Review change requests (as appropriate) and support the change control board as requested.
10. Support the preparation, review and approval of project completion and closeout documentation.
11. Delivery of a quality, cost effective product.

Key IPT Members

The following are key members and positions on the initial NOνA Integrated Project Team

- Michael P. Procario, DOE OHEP Program Manager
- Pepin Carolan, DOE Federal Project Director, IPT lead
- Stephen Webster, DOE Deputy Federal Project Director

- Dennis L. Wilson, FSO Business Manager**
- Jonathan P. Cooper, FSO ES&H Lead+
- Barbara Lewandowski, CH Procurement
- James Fuerstenberg, CH legal
- John Cooper, NOνA Project Manager ++
- Ron Ray, NOνA Deputy Project Manager
- Nancy Grossman, NOνA Associate Project Manager
- University of Minnesota DOE Cooperative Agreement Awardee/Principal Investigator

* *Warranted contracting officer within the Fermi Site Office; it is anticipated that an FSO business team vacancy will add FSO Procurement Specialist support when filled.
+ Will coordinate FSO ES&H team support as needed.
++ In addition to leading the project management team, coordinates necessary project Support from Fermilab business, procurement, legal, ES&H and other Division/Section support as needed.

As the project progresses, membership of the IPT will change as needed.

Primary Team Interfaces

Multiple interfaces are necessary for the NOνA IPT to ensure well-coordinated timely project performance. These include the Office of High Energy Physics (OHEP), Program Manager for Fermilab/ NOνA, other DOE Headquarters Program and Project Management organizations, the NOνA Project Management Group (PMG), the NOνA Level 2/subsystem Managers, the NOνA experiment collaboration, and the Institutional DOE Cooperative Agreement Awardee responsible for the proposal to construct the far detector enclosure and participate in operations.

The Federal Project Director (FPD) will be the primary point of contact with the OHEP Program Manager for coordination and submittal of CD documentation. The FPD will also routinely contact the OHEP Program Manager to communicate project status and discuss issues or concerns. Input will also be solicited from the OHEP Program Manager on institutional developments that may impact project execution or performance.

Interface with Fermilab management and affected personnel will be necessary for coordination with site activities that may impact project execution or performance or where project activities may have broader site impacts. Within Fermilab, this includes multiple interfaces among the Fermilab Directorate; Particle Physics, Computing, and Accelerator Divisions; and ES&H, Facilities Engineering Services, and Business Services Sections. The NOνA Associate Project Manager plays a key role in managing

the interface between the NOνA Project and Accelerator Division to ensure necessary coordination, planning and availability of resources for the NOνA accelerator and beamline work. The PMG will play a key role overall in coordinating these interfaces and resolving issues that may arise.

For DOE CD approvals and project reviews, the FPD will interface directly with other DOE headquarters Program and Project Management organizations as necessary. However, the OHEP Program Manager will be the IPT point of contact for day-to-day interface with these organizations.

The NOνA Level 2/subsystem Managers will be responsible for implementing project elements of work. The NOνA Project Manager and/or IPT team members directly associated with the elements of work being performed will be the primary points of contact with the NOνA Level 2/subsystem Managers.

The NOνA Collaboration provides guidance on the scientific and technical goals of the NOνA project and participates in the design, construction and testing of NOνA components. The NOνA co-Spokespersons will be the primary points of contact with the NOνA collaboration.

There is a key interface between the NOνA Project Manager and the Institutional DOE Cooperative Agreement Awardee responsible for the proposal to construct the far detector enclosure. This interface will be managed to ensure coordinated execution of authorities among the parties, and to maintain adequate communications, work authorizations and flow, and project controls and reporting to cover design, construction and oversight activities.

Meetings

The IPT shall meet as necessary to accomplish the stated goals and mission. Team members shall meet with each other and external interfaces as necessary to resolve specific issues.