Department of Energy
Review Committee Report

on the
review of

NuMi Off-Axis Neutrino Appearance (NOνA) Experiment

April 2006

EXECUTIVE SUMMARY

On April 4-6, 2006, a Department of Energy (DOE) Review Committee conducted a review of the Neutrinos at the Main Injector (NuMI) Off-Axis ν_e Appearance Experiment (NOνA) Project at Fermi National Accelerator Laboratory (Fermilab). By the request of Dr. Robin Staffin, Associate Director for the Office of High Energy Physics (HEP), the Review Committee was chaired by Daniel Lehman, Director of the Office of Project Assessment. The purpose of the review was to validate the conceptual design and the cost range, which are needed for Critical Decision (CD)-1, Approval of Alternative Selection and Cost Range.

The Committee was asked to verify that the conceptual design of the project adequately addressed the technical requirements; that the estimated cost and schedule ranges were reasonable; and that there was a team capable of managing the project to a successful completion. The Review Committee was comprised of 16 technical and management experts from DOE national laboratories, DOE headquarters, and U.S. universities.

The NOνA project proposes to utilize the existing NuMI beamline and construct two new detectors optimized to detect electron neutrino interactions in order to observe the oscillation of muon neutrinos into the electron neutrinos and measure the parameters of that oscillation. One detector would be located on the Fermilab site and one would be approximately 800 kilometers away on a site to be determined in northern Minnesota.

Overall, the Committee judged that the project is ready for CD-1. The Conceptual Design Report is complete and comprehensive. The cost and schedule ranges are appropriate.

The Committee was impressed with the competence, depth of knowledge, and extensive experience of the scintillator team in performing physics experiments with liquid scintillator (LS) and wavelength-shifting fibers (WLSF). The conceptual designs for the WLSF and the LS are much more thorough and detailed than are required for CD-1.

The Committee commended the project's progress on Poly Vinyl Chloride (PVC) modules and their approach to PVC extrusion procurement. Exceptional progress has been made on the Far Detector assembly planning. The Near Detector is not as well advanced, but is adequate for CD-1. Electronics and data acquisition have an experienced team and detailed design is available for most components.

The project team has developed a conceptual design for the site and building at the proposed Ash River site. The site was selected as the best of five proposed sites. Preliminary borings have been completed at the site and additional geotechnical borings are planned. The proposed building conceptual design meets the technical performance requirements to enable installation and operation of the NOνA detector.

An Architect/Engineer (AE) will be used to evaluate the schedule and prepare an independent cost estimate. Additionally, the AE will be used to prepare the 30 percent design package. The schedule illustrates the 30 percent design starting in October 2006, with completion by January 2007.

DOE plans to solicit proposals for a cooperative agreement with a third party to manage the design build contract for the facility and later the operations of the facility.

The Committee found the cost estimate to be well-advanced for this stage of the project. The Total Project Cost range of $197-$256 million is reasonable. The range could be used as a basis for requesting CD-1, if supported by an appropriate funding profile. The project is using an acceptable methodology of contingency. Assessment is reasonable in most areas.

The Committee found the 50-month schedule for a 25kT detector to be reasonable at this stage of the project.

The proposed cooperative agreement for the building site and construction appears to be on the project critical path. Exact site and acquisition strategy will be needed at CD-2, Approve Performance Baseline. The adequacy of R&D—PED (Project Engineering and Development) funding is dependent on resolution of acquisition strategy. A firm funding profile for the project has not been established.

NOνA management and staff vocalize and demonstrate support of Integrated Safety Management functions and principles. The Environmental Safety and Health aspects of NOνA have been adequately addressed for this stage of the project.

A NOνA Project Management team is in place and functioning well. The documents needed to complete the CD-1 process have been identified—most of the documents have been completed. The remainder of the documents are in final draft status and require input from HEP and the Fermilab Site Office (FSO).

The Project Management team has a clear timeline for Critical Decisions (e.g., CD-2) and the related reviews.

There were no action items resulting from the review.

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1. INTRODUCTION

The Neutrinos at the Main Injector (NuMI) Off-Axis Electron Neutrino Appearance (NOνA) Experiment is a proposed alternative being considered for the Electron Neutrino Appearance (EνA) project. The Department of Energy (DOE), Director of the Office of Science (SC), Raymond Orbach, approved Critical Decision (CD) 0, Approve Mission Need, for EνA on November 25, 2005. The NOνA proposal utilizes the world's most intense neutrino beam, the NuMI neutrino beam at Fermi National Accelerator Laboratory (Fermilab) and will create a new large (20-30 kiloton) neutrino detector that is optimized for the detection of electron neutrinos.

The Office of High Energy Physics (HEP) requested that the Office of Project Assessment conduct a review of the project in preparation for CD-1, Approve Alternative Selection and Cost Range. The review was held on April 4-6, 2006 and was chaired by Mr. Daniel Lehman. The purpose of the review was to verify that the project's technical design adequately addressed the technical requirements, the estimated cost range was credible and sufficiently documented, and there was a team capable of completing the design of the detector and developing the technical, cost, and schedule baseline needed for CD-2, Approve Performance Baseline.

The NOνA project consists of a Near Detector on the Fermilab site, a Far Detector located 700-800 kilometers (km) away in Northern Minnesota, and a detector hall for that detector.

<u>NOνA Far Detector:</u> The NOνA Far Detector is optimized for detecting low-energy (approximately 2 GeV) electron showers while rejecting background events. High-signal efficiency and good background rejection require frequent sampling in materials with low atomic number.

The Far Detector will be a 20,000-30,000-ton tracking calorimeter, measuring 15.7 by 15.7 meters and more than 100-meters long. It is constructed from alternating vertical and horizontal cells of liquid scintillator (LS) contained in rigid plastic extrusion modules. A wavelength shifting fiber (WLSF) is inserted into each LS cell and terminates on a pixel of a 32-pixel Avalanche Photo Diode (APD) chip. The APD is followed by front-end electronics that amplify, multiplex, digitize, and zero suppress signals before passing them to the data acquisition system.

NOνA Near Detector: The NOνA Near Detector will operate on the Fermilab site at a distance of about 1 km from the NuMI target in the existing NuMI access tunnel. The purpose of the Near Detector is to measure backgrounds to ν_e identification that will appear in the Far Detector. The NOνA Near and Far Detectors are nearly identical. The only significant differences are the size, the clock speed of the electronics, and the requirement that the Near Detector be mobile.

Far Detector Hall: The NOνA project requires construction of a detector hall in Northern Minnesota to house the NOνA Far Detector. The building will also include adequate space and infrastructure to facilitate construction and operation of the Far Detector. Most of the Far Detector hall will sit below grade. The exposed sides and top of the hall will be covered with a three-meter overburden of dirt and rock to shield against cosmic rays.

2. TECHNICAL

2.1 Scintillator and Fiber

2.1.1 Findings

The Committee was impressed with the competence, depth of knowledge, and extensive experience of the scintillator team in performing physics experiments with LS and WLSF. This experience and expertise was obtained in previous, successful experiments, such as the Main Injector Neutrino Oscillation Search (MINOS), the Neutrinos at Tevatron experiment (NuTeV), and the Monopole Astrophysics and Cosmic Ray Observatory (MACRO). The proposed NOνA conceptual design for the LS and WLSF is a natural extension of this work.

The conceptual designs are excellent and satisfy the NOνA performance requirements. In particular, the composition, preparation, and performance of the LS and WLSF have been well studied and researched. Also well understood are the blending of the LS components, the testing and quality control associated with each step in the blending procedures that lead to the final LS mixture, the transport of the LS to the far-detector site, and the loading of the detectors at the far and near sites.

The scintillator team is properly addressing various environmental safety and health (ES&H) issues, such as fire prevention and prevention of LS release into the environment. The present cost and schedule estimates seem to be reasonable; the costs of several major components are based on quotations from oil and fiber vendors.

2.1.2 Comments

The conceptual designs for the WLSF and especially for the LS are meticulous and detailed more than what is required for CD-1. Nevertheless, further R&D is required over the next year to finalize the specifications for the WLSF. The WLSF delivery schedule is on the critical path and the cost of the WLSF has increased significantly in recent months. It is prudent to explore proposals from more than one vendor.

For future CD-2/CD-3, Approve Start of Construction, reviews, it will be important to complete the following actions:

1. Perform aging tests on prototype extrusion cells with LS and WLSF, as soon as the specifications for all materials are finalized, to ensure compatibility.

2. Periodically check the light output and attenuation length of archival LS and WLSF samples as a function of time. Ensure that the light output and attenuation length will not change with time, especially if the data were to indicate any deterioration in the properties of the LS and/or WLSF.

3. Determine plans for clean-up of oil spills of a few gallons or more at the Near and Far Detector sites and at each location where the LS is being handled and blended, including the transport and transfer of the organic liquids.

2.1.3 Recommendation

1. The Committee recommends approval of CD-1.

2.2 Mechanical and Assembly

2.2.1 Findings

PVC Extrusions

The mechanical group has developed a robust design for the modules and overall detector, with a strong development and prototyping program.

The design of the extrusions and module block assemblies shows good communication and optimization among the analysis, design, and integration groups. The extrusion design and preliminary assembly plans are structurally clean designs, and the test and prototype plans presented are intended to work down the open materials and structural design technical risks before CD-2.

The prototyping and testing of the Poly Vinyl Chloride (PVC) resin mix has been commendable. The project has investigated many material mixes to optimize reflectivity and cleanliness while ensuring high quality and well-controlled processes. The candidate mixes of PVC do not appear to put stringent process control requirements on the extruder. This should keep the yield and quality high, once the process is finalized by the extruder. This is important to ensure controlled processes and smooth extrusion contracts.

Panels are extruded at a rate of 1000 lbs/hr, which is about one vertical panel per hour. Typical tolerances are +/- 0.25 mm or larger. No extruder is currently set up to extrude the 52-inch width needed for NOνA modules, but the equipment is available and two companies are prepared to add the infrastructure to one of their lines. While this is a large job, it does not particularly tax the capability of either of the companies under contract. One extruder, in particular, has been supportive of the R&D effort.

The feasibility of 16-cell modules was investigated, to remediate any 32-cell unit production problems. The 16-cell extrusions are within the current capabilities of many manufacturers. The biggest potential problem is the assembly manpower and flow, and how to integrate the electronics. The project is looking at options if this needs to be implemented, but do not have any indication that this will be a problem.

An epoxy joint thickness test program is under way, to investigate the impacts of 0.1 to 2.0 mm bondline thickness at the module-to-module face joints. This is an important test program to complete, since the results may affect the needed/allowed tolerances of extrusions and mating parts. Epoxy is applied to the bottom with a roll-coater. Module extrusions are shown to be flat enough to ensure a maximum bond line of 0.010. As a remediation, weights can be added on the top and/or add beads to ensure a minimum bond thickness.

PVC Modules

The module construction team presented the current status of the module design and plans for the module assembly process at three factories, two universities (The University of Minnesota and Michigan State University) and one at Fermilab or Argonne National Laboratory.

The module consists of the PVC tube extrusion, the machined-out bottom seal plate and a multi-extrusion manifold that provides a protected path for the WLSF from the scintillator cell to the photodiode detector mounting block, as well as an attachment point for the oil fill and overflow system. Progress was made on the engineering design of the manifold components, relying on experience gained in the design and construction of the MINOS plastic scintillator detector modules for the manifold design. Finalization of the bottom plate design can occur only after trial assembly of modules with the 16-cell prototype tube extrusions, which will be available summer 2006. The plate will be machined at Fermilab. The team expects that this will have a lower cost than injection molding, which surprised the Committee. Quotes for both production processes should be available for the CD-2 review.

The team has a well-planned process for identifying and evaluating the properties of glue that will be used to fasten the bottom plate and manifold.

Module assembly time-and-motion studies are well advanced for this stage of the project. More complete and detailed planning is needed for CD-2, and much of the prototyping effort scheduled for this summer will allow evaluation of the details for final design and production.

The plan for each of the three factory sites is to have a three cell assembly area with crane rails spanning the area. Two bridge cranes with manual trolleys will be shared among the three cells. These cranes will be used to move the 15.7-meter long, 1.3-meter wide, 32-cell modules across the bay for the stages of assembly. Each of the (approximately) 21,000 modules will be moved at least twice.

The assembly process will take place on "tables" within each assembly cell. The tables need to be low to accommodate movement of modules by the crane within the bay. Module extrusions will be checked for shipping damage on receipt from the extruder. The WLSF will be batch sampled for quality. In the module assembly process, the WLSF loop will be drawn with a vacuum device from one end of the tube to the other using a "puck". The fiber will be looped around the puck. The bend radius of the fiber imposed by the dimensions of the tube is somewhat tighter than the fiber manufacturer's minimum suggested bend radius. After fiber stringing, parts of the manifold will be set in place. The fiber ends at the manifold end of the module will be routed to the photodiode interface plate. The continuity and mapping of the installed fibers will be checked. The bottom plate and the manifold will be glued in place. The fibers in the interface plate will be faced off to accommodate the mounting of the photodiode. The completed module will be tested for leaks at an established sensitivity of .1 liter/year. Modules will be placed on specially designed pallets with incorporated lifters, moved into a truck and shipped to the site of the experiment.

Near/Far Detector Assembly

The Far Detector, which is 25kt and is 73 percent active, consists of 54 blocks, each of which is composed of 31 alternating vertical and horizontal planes. The task for the Far Detector Assembly team is to receive and ensure quality assurance (QA) for the 32-tube modules from the factories, the readout hardware, and the LS. Twelve of the modules are assembled into a plane on the elevated work surface provided by the block raiser. The modules of the next plane are covered with glue as they are passed through the commercial roller coater, and are assembled at right angles onto the preceding plane. This process is continued until layer 31 completes the

block; it is expected to take one week once the process has become routine. After a weekend for the glue to dry, the block is rotated vertically and moved into place separated by a thin spacer, which provides lateral stability from the preceding block. After several additional blocks are installed, the first block is filled with oil. The detector is outfitted with the avalanche photodiode (APD) readout module and electronics, cabling, power, and cooling.

The structural engineering for the detector is well advanced. The number of planes in a block is set by the requirement that the safety factor against buckling be at least five, as well as the need to limit propagation of swelling after filling. Horizontal extrusions are supported by the vertical modules. The vertical extrusions have thicker walls than the horizontal extrusions to reduce adhesive shear stress. Two glues were identified, which meet the structural requirements; one of these is preferred for being more ES&H friendly. Seismic concerns were briefly discussed during the review. There were no issues here, since the areas in which the detectors will be installed are classified as zero. This significant design consideration should be mentioned in the Technical Design Report.

Time-and-motion estimates for the assembly process are well developed, and include 14 weeks to set up the equipment, 42 weeks to "ramp-up" to full crew operating at the full block production rate, 42 weeks at the rate of a block per week. The assembly endgame has 9 weeks for ramping down the crew size and production rate, 4 additional weeks to complete the fill, and 3 weeks to complete outfitting.

The block assembly includes lifting of the assembled PVC modules using a vacuum lifting device. Again, there is the potential for at least two times 21,000 lifting operations, and safety will require a high-quality inspection and maintenance plan for these lifting devices. Once the blocks are in place, the utilities will need to be connected. This aspect of the installation is not yet developed. The Committee envisioned issues with access, especially to the top of the block for connection to the vertical modules, although the sides were not addressed. Connection of the cables and filling hoses will impose stresses on the module composite components. Once in place, it will be very difficult, if not impossible, to repair or replace these parts. Proper strain relieving is necessary to protect the module integrity.

The filling operations were described and appeared detailed. However, structural analysis indicated that the vertical modules are to be filled first, but evidence showed the horizontal modules being filled first. The proposed filling operation will free-fall the mineral oil scintillator the 15.7m height of the vertical modules. This may pose hazards from static electricity. Flammable liquid standards require that tanks have a tube going to the bottom of the

tank for filling. Fill sensing was mentioned, but is not yet developed. Fill sensing is an important feature of the filling operation to prevent overfilling, over pressurization and spillage, and may present a challenge for a closed-loop filling system. The filling and the utilities installation both require a systems engineering effort to coordinate and address the installation and integration process.

ES&H has received careful consideration. The assembly task involves operation of heavy equipment; movement of heavy object; working in high places; use of adhesives with fumes; and LS spills that need to be contained. The route to ES&H success is recognized to be worker training and certification, procedures, monitoring and personnel protection equipment, as well as monitoring from safety officers and involvement of management.

The detector assembly task is responsible for overall detector integration. To support this activity, the team meets regularly with the other task managers; in particular, with the Far Detector site construction team.

The Near Detector, which weighs 209 tons, has a geometry that is similar to that of the Far Detector to duplicate the response of the Far Detector. The detector must physically fit into the MINOS underground enclosure with only limited changes due to its shared use with existing detectors. The location deep underground in tight quarters adds a special ES&H burden; in particular, scintillator containment and its compatibility with life safety. An additional constraint is that the detector must move over a limited range in the access tunnel. The detector is segmented into parts that can be lowered down the existing shaft. These requirements lead to assembly out of seven and eight plane modules, each 2.9m x 4.1m, which are mounted in cradles. There are 24 of these modules. Finally, there is a muon catcher section unique to the detector that consists of ten steel plates, each with a module plane attached. The total length of this detector is 14.4m. The Integration Prototype Near Detector, which will be located in the MINOS Service Building at Fermilab, will be used as a test bed for the detector elements; in particular, those of the Near Detector.

2.2.1 Comments

The Committee commended the team's approach to extrusion procurement in both the optimization of the resin for mechanical and reflective properties (with the help of a PVC expert) and engagement with vendors to develop extrusion production.

The Committee suggested that the team:

- Complete an evaluation of the tradeoffs between the choice of 16-cell versus 32-cell extrusions. It was expected that the 32-cell extrusion would lead to lower cost; however, the die costs for this extrusion are very high, and it was unclear that this cost would be offset by lower labor costs.

- Give higher weight to PVC mixtures that are easier for the extruders to work with, that are consistent with acceptable physics performance, in order to maintain better process controls on the extrusion process.

- Complete material properties testing in longitudinal and transverse directions to confirm PVC extrusion material anisotropy properties.

- Use the 16-cell extrusions to develop the QA plan (needed for ultrasonic or weight inspection, and/or thickness measurements at the extrusion ends good enough?); and

- In future revisions of the Conceptual Design Review (CDR), if any, add further detail on structural analysis, including margins, and methodology, as well as stress margins on minimum dimensions. The structural analyses are more advanced than the CDR would lead one to believe. The Committee heard that the structural analyses were completed for the worst case tolerances, and an adequate safety factor exists. This is very positive, and should be documented in the CDR to demonstrate the design is well advanced.

The Committee noted that 1) the cost, cost basis, and contingency estimate and schedule appear reasonable, and 2) the task manager shows good connection to the schedule.

The Committee commended the team for their effort and progress on the PVC Modules, and stated briefly that:

- Labor estimates for module assembly appear to be lean.
- Although 100 percent contingency on labor for assembly seems high, the time allotted for the tasks appear tight, so that the high contingency is justified.
- Additional engineering effort should focus on module assembly time and motion studies.
- The project should consider increasing the number of bridge cranes to one per assembly cell and include stops to limit trolley travel in each cell.
- Scissor tables for module movement and assembly should be considered.
- The project should make use of design tooling to clamp the end plug manifold and bottom plate to the extrusion during gluing.
- The epoxy for vertical curing should be evaluated and defined.
- The methodology for the cost estimate appears adequate.

- The task manager illustrated high-quality connection to the schedules.
- Manpower appears to be adequate to receive CD-2 approval. The project realizes the need to hire the first factory manager immediately.
- Structural analysis support appears thin and the project should evaluate the engineering manpower profile between the R&D and production phases for continuity.

Time and motion studies for some assembly steps were very well done, but are incomplete. The routing of the fiber into the manifold is advanced, as is the testing plans for the modules through their various phases of construction. A similarly thorough assessment for all phases of module assembly is needed for CD-2. The prototype effort scheduled for this summer should provide significant insight into the steps necessary to properly assemble and test functional modules. The prototyping effort should include time and motion definition as one of its objectives.

Of concern during this review was the handling of the (approximately) 900-pound extrusion/module. Pushing and pulling these loads overhead on the manual trolley can pose ergonomic issues, since the loads are relatively high. This process is likely to be repeated at least twice for each of the (approximately) 21,000 modules. There may be strain related injuries to personnel due to starting and stopping movement of the half-ton of the module and the lifting fixture. There is also great potential for collision of the extrusion or lifting fixture with the crane support structure. Stops at the ends of each cell would eliminate the potential for this event. The Committee recommended stops and three cranes, for each cell.

Using vacuum fixtures is an acceptable industrial material handling method. However, with (approximately) 21,000 modules each moved multiple times, special care must be taken of the vacuum fixtures. The extrusions do not have a uniformly flat surface across its entire width, owing to the grooves at the webs of the extrusion cells. Further, the vacuum fixtures do not provide a positive mechanical attachment that can withstand long-term use and abuse. Frequent, complete maintenance and inspection will be necessary to assure proper function and operation of the vacuum lifting devices and to minimize the potential for a material handling incident.

The assembly process will primarily be done on “tables” within each assembly cell. The tables should be low to accommodate manual movement of the cranes, but may be too low to work on without ergonomic impact. The positioning of the extrusion for assembly should be evaluated for an ergonomically friendly position.

The use of scissor tables or other devices may be useful to achieve proper positioning.

The project proposes to use the WLS fiber at a bend radius smaller than the minimum recommended by the manufacturer. The manufacturer has been consulted by the team, and responded that the intended bend radius should be acceptable. However, the team should fully evaluate this use to assure the fiber integrity is maintained. Damage to the coating of the fiber will not be discovered until filling, which would cause significant work to repair, if in fact it could be repaired in situ. There is significant potential to cause further bending of the fiber during filling and during shipping. For this reason, additional effort is necessary for a "fiber retainer" alluded to during the breakout sessions. The Committee felt that the "fiber retainer" is necessary to maintain the maximum bend radius possible once installed in the extrusion. This retainer would be permanent (glued into position at the end of the tube). It may or may not be a part of the fiber installation tooling (hockey puck).

The module will have a bottom plate and manifold glued to the ends to form the container for the LS. This step requires clamping these parts in place on the tube extrusion until the epoxy is cured. The pressure test of the modules requires some type of containment in the event of a failure of the end cap glue joints. Other fixtures for the installation of the fiber and electronics were also discussed extemporaneously. It may be possible to incorporate all functions into one device. This particular instance also emphasizes the need for stronger system engineering to bring together the needs of different groups into integrated devices and designs in order to reduce manpower, cost, and time.

Though much documentation of analyses and investigations done by the team exists, this was not made known to this committee until the day before the review. For future reviews it would be useful to make these documents available to the reviewers earlier.

The Committee also noted that:

- Progress was made on the Far Detector. The Committee was impressed with the level of detail in design and assembly planning. The level of maturity is close to the CD-2 level.
- Additional work is needed in design of the interface between detector modules and detector utilities. This work depends on a better understanding of the interaction of platforms provided as part of the outfitting of the Far Detector building with the detector and its services.
- Near Detector design did not seem as far advanced. Proportionately more effort is needed to receive CD-2 approval.

- The cost estimate appears to be credible.
- The installation schedule and manpower is well developed and credible.
- The task manager illustrated high-quality ownership of the schedule.
- The use of a consultant to assist in the evaluation of scintillator handling was an effective decision made by the team.

The Committee suggested that the team: 1) evaluate the need for edge stiffeners; 2) consider leasing a roll coating machine for prototype effort; 3) develop detailed procedures for filling the modules to assure proper process and sequence (there should be no confusion regarding filling order); and 4) complete the life safety evaluation, to include Near Detector containment.

2.2.3 Recommendations

1. Recommend CD-1 approval for the PVC Extrusion.

2. Recommend CD-1 approval for the PVC Modules.

3. Revisit the time and motion studies for module assembly using experience gained with 16-cell extrusions.

4. Perform an ergonomic assessment for module assembly; in particular, the manual trolley crane movement.

5. Develop a plan for use and maintenance of the vacuum lifters.

6. Design the fiber retainer to maintain fiber bend radius for filling and during transportation.

7. Recommend CD-1 approval.

8. Develop designs for strain relief of utilities on modules.

9. Develop designs for access to install utilities on the top and sides of modules blocks.

10. Develop a plan for use and maintenance of the vacuum lifters.

11. Reinforce the systems engineering team at the project management level for control of interfaces.

12. Evaluate filling operations for static electricity hazards.

13. Develop a more robust plan for sensing liquid level during detector filling.

2.3 Trigger and Data Acquisition

2.3.1 Findings

The electronics system (Work Breakdown Schedule [WBS] 1.6 and 2.6) includes (approximately) 20,000 APD modules, and approximately 20,000 readout front-end electronics boards, cooling, and low- and high-voltage supplies including distribution system.

Data Acquisition (DAQ), WBS 1.7 and 2.7 includes the DAQ software, the DAQ hardware comprising 324 data concentrators, (approximately) 20 Gigabit Ethernet switches and a computer farm with (approximately) 260 processors. Included in this project are cables, the slow control system, the online databases, and the integration effort.

Electronics System

The electronics system consists of (approximately) 20,000 copies of a 32-channel front-end electronics module. Each module contains one 32-pixel APD detector and one printed-circuit board comprising one 32-channel analog amplifier Application Specific Integrated Circuit (ASIC) with on-chip readout multiplexer, one four-channel analog-to-digital converter chip, and one control/readout Field Programmable Gate Array (FPGA) with high speed serial interface.

<u>Avalanche Photo Diode:</u> The proposed device is a modified version of an existing Hamamatsu device. The modification is necessary mainly to accommodate two fiber ends for each pixel. Detectors for evaluation were ordered and are expected in summer 2006. The detectors will be bump-bonded on NOνA-supplied, printed-circuit boards by Hamamatsu. Subsequently, the remaining board components including cables are assembled. There are some concerns about the proximity of some bump-bonds to the detectors with an approximate 500V potential difference between them. This could be a leakage current path that may need to be addressed. Prototype electronics for evaluation should be available in summer 2006 well before the required CD-2. The module/detector integration and the fiber/APD alignment needs more

detailed design work, but is not considered a large risk. The detector package includes a thermo-electric cooler whose reliability might be an issue. First estimates show that as many as three packages would have to be replaced every day. The devices are readily accessible, but accelerated tests are planned to understand the failure rate under the more benign NOνA operating conditions. The cooler is necessary to operate the APDs at -15° C to achieve a signal-to-noise ratio of 10:1.

Front-End Board: This is a straight-forward board with a custom Integrated Circuit designed by Fermilab, a 12-bit ADC (Analog to Digital Converter) and an FPGA. The ASIC is based on an existing design that was adapted for NOνA. A first prototype was received and measurements are being performed. A second prototype iteration is in the project schedule in case modifications are required. The signals from the detector are continuously digitized and processed in the FPGA. Only signals above threshold are packaged with a time-stamp and channel identification and forwarded to the DAQ system. Data rates of <1.5 MB/sec are estimated from each front-end module that has a low enough rate to not be considered a cost or schedule driver. The details of communication and dataflow to/from the DAQ system require resolution.

Power Supplies: The high- and low-voltage supplies are purchased from known suppliers and are not considered a risk. The distribution system consists mainly of point-to-point cables.

Data Acquisition

The 20k front-end boards are controlled and readout via 324 Data Concentrator Modules (DCM). The DAQ modules are connected via commercial Gigabit Ethernet switches to a processor farm. To make effective use of the available bandwidth, the Data Concentrators buffer event data so that larger packages can be transmitted to the processor farm. Time stamp information and a predefined round-robin algorithm are used to select the target node. For each one-second time interval, data from every DCM are sent to a single node in the processor farm. This node serves as the primary buffer for the data for this time slot. When a spill signal arrives from the Fermilab Main Injector, the data are extracted from the buffer memory and forwarded to a data logger system. In addition, part of the DAQ is a Clock and Control System that is used to distribute commands, clocks and synchronization signals to the DCMs, front-end boards and the processor farm.

The DAQ system is designed to handle an input rate from the detector of 3.5 GB/sec or 12 MB/sec per DCM. The rate to the data logger, including calibration data, is less than 2

MB/sec—a prototype DCM is under development. A conceptual design exists for the Clock and Control system. The network switches and the processor farm are commercial products.

The components of the readout and control software and the online databases will be developed in three releases—the first one is due at the end of 2007 in time for the IPND (Integrated Prototype Near Detector) test. The architecture and the functionality of the proposed system are adequate for NOνA and fulfill the requirements.

The number of full-time employees (FTE) working on the DAQ software appears to be extremely low to be able to deliver the proposed system on schedule. It is estimated that the group needs at least one or two additional FTEs as soon as reasonably possible.

General Findings

A WBS to Level 6 was presented including a detailed Basis of Estimate work-book. The project is divided into two phases—R&D and construction. The R&D phase lasts through end of FY 2007 and the construction phase is estimated to about 2.5 years. No contingency is included for the R&D phase.

R&D phase is estimated (in FY 2006 dollars) at $3.75 million (Electronics: $2.14 million and DAQ: $1.61 million) and the construction phase at $23 million (Electronics: $20.3 million and DAQ: $2.7 million). The electronics construction includes 47 percent contingency, the DAQ includes 23 percent contingency with only eight percent contingency assigned for DAQ software labor.

Most of the design work will be completed in the R&D phase of the project with some of the DAQ software development continuing during the construction phase.

Cost-drivers are the APDs and front-end board costs, as well as the readout infrastructure that includes the high- and low-voltage power supplies, cooling, and power distribution. All of these are largely supported by vendor quotes.

With the exception of the DAQ software no labor profiles were presented.

2.3.2 Comments

The Electronics and DAQ individuals working on NOνA are very experienced and the technical challenges are considered to be well within the capabilities of the group.

The designs presented for the front-end electronics and the DAQ system provide sufficient throughput and flexibility to meet the (scientific) requirements of the NOνA experiment. No technical hindrance was identified.

The APDs are single-vendor sourced (Hamamatsu). However, this is not unusual for silicon detector devices for high energy physics and is not a high risk. Hamamatsu has already redesigned their APDs to fit the NOνA design. If another iteration is required due to NOνA-driven modifications, a new mask set (at a cost of about $200K) would be needed.

The ASIC is not considered a technical risk, but could impact the schedule if additional iterations are required. However, this is not considered very likely since the performance and complexity seems to be well within the capabilities of the design team.

The noise performance required appears achievable and digital processing can improve the result if required.

In general, it unclear what are the reliability requirements for the 20,000 electronics packages are (i.e., How many packages can be non-functional before they need to be replaced?). The requirements should be provided by systems engineering. All electronics are accessible, thus it is a mainly a question of maintenance efforts.

The high-voltage supplies can source currents up to 15 mA per channel. The safety measures required for inclusion in the design of the high-voltage distribution system needs clarification.

For the Near Detector, the project should illustrate that the probability of over-lapping signals in a detector element is negligible or effort needs to be budgeted to modify the front-end electronics boards for the Near Detector.

Electronics calibration also needs to be defined in more detail and related software should be included in the plan. The DAQ system provides sufficient throughput and flexibility to meet the requirements.

Data flow control and synchronization; in particular, between the front-end boards and the DCMs, should be further developed by the time of CD-2.

The schedule to deliver a functional DAQ system in time for the IPND test is very tight. A great deal of the software development for the DAQ system is scheduled to occur during the R&D phase. The Committee was concerned that the FTE estimates for this subproject was extremely low. If possible, an additional software engineer should be added to this effort soon.

Responsibilities for database design and maintenance among the sub-projects should be clarified. As presented, the DAQ WBS does not provide (sufficient) support for the hardware databases that require remote access, special data entry hardware, etc. Until the project decides to use an open-source database management system, the license costs for a commercial product such as Oracle should be included. Given the importance of databases for quality control and QA, as well as general bookkeeping during the construction phase, the Committee recommended adding additional database expertise to the project.

For slow-controls, the project is looking for additional collaborators, which should help to complete the design of the system in time for the CD-2 review.

Only an initial concept exists for the data archival system at the NOνA site, as well as the connection to Fermilab. Provided the low-data rates, this is not considered a risk.

In general, the information was well presented to the Committee. For the hardware projects, the estimated cost seemed very appropriate. For CD-2, the WBS might need another internal review to ensure that there are no oversights. The Committee recommended including columns for man-hours and resource information on the spread-sheet listing the cost.

Off-project labor (e.g. physicists) is not included in the current WBS. Combined with the fact that for most sub-project labor, profiles were not available during the review. This made it difficult to assess if sufficient personnel were assigned to these projects. The Committee suggested making this information more readily available for future review.

Overall, the presented schedule appears to be credible.

2.3.3 Recommendations

1. Include off-project labor (e.g. physicists) access to review the man-power resource estimates.

2. Consider the suggested increase in software man-power to meet the presented schedule.

3. The Committee recommends CD-1 approval.

3. CONVENTIONAL FACILITIES

3.1 Findings

The project team developed a conceptual design for the site and building at the proposed Ash River site. The site was selected as the best of five proposed sites. Preliminary borings were completed at the site and additional geotechnical borings are planned.

A bottoms-up estimate was prepared by the project team. The contingency was assigned using guidance from the DOE cost estimating guide. The schedule was developed by the project team but does not reflect the recent decision to use a design build contract strategy.

An Architect/Engineer (AE) will be used to evaluate the schedule and prepare an independent cost estimate.

Value Engineering studies were conducted for the roof structure and the aisle access. The AE will perform additional studies of the secondary containment and the cut and fill optimization.

An AE will be used to prepare the 30 percent design package. The schedule shows the 30 percent design starting in October 2006, with an expected completion in January 2007.

DOE plans to award a cooperative agreement with a third-party to award and cooperatively manage the design build contract for the facility.

The risk assessment was documented in the CDR.

3.2 Comments

Evaluation and selection of the preferred site (Ash River) and alternative site (Orr-Buyk) was based on a sound decision and information gathering process.

The use of an AE to do an independent review of the conceptual design estimate and schedule is commendable. The schedule should be revised to reflect the proposed design build contracting method.

The project should prepare a comprehensive risk assessment prior to CD-2.

A contingency analysis should be completed based on identified project risks. A Monte Carlo analyses methodology should be used to evaluate the adequacy of the contingency.

The 3-meter rock overburden on the Ash River building has a cost impact of $6-7 million on the cost of the facility. This should be evaluated in more detail to determine if a more cost effective alternative could be found.

The proposed building conceptual design meets the technical performance requirements to enable installation and operation of the NOνA detector.

The project CDR and supporting documents justify the proposed cost range and project duration.

3.3 Recommendation

1. Recommend approval of CD-1.

4. COST ESTIMATE

4.1 Findings

The cost estimate for the NOνA construction project was developed using a comprehensive task oriented WBS summarized below:

Table 4-1. NOνA Work Breakdown Structure

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	PVC Modules
WBS 2.6	Electronics Modules
WBS 2.7	Data Acquisition Strategy
WBS 2.8	Near Detector Assembly
WBS 2.9	Far Detector Assembly
WBS 2.10	Project Management

Included in the project's Total Project Cost (TPC) was WBS 1.X, R&D and Project Engineering and Design (PED) estimates. The project team presented a TPC range between $197-256 million (actual year [AY]) for the NOνA project. The best estimate was $247 million (AY), which includes 35 percent (approximately $64 million) contingency.

The project's cost and schedule estimates were presented down to WBS Level 5 in most areas, with some areas to Level 8. Quotations and other pricing were compiled to establish a base cost in FY 2006 budget. The Project Office will centrally manage the project controls software (Open Plan and COBRA). A summary of the NOνA preliminary estimate of project costs is shown in Table 4-2.

Table 4-2. NOνA Project Cost Breakdown (AY$ in Millions)

WBS	ITEMS	Total Project Cost
2.1	Far Detector Site and Building	$39.7
2.2	Liquid Scintillator	$41.7
2.3	WLS Fiber	$26.2
2.4	PVC Extrusions	$47.8
2.5	PVC Modules	$15.4
2.5	Electronics	$21.8
2.7	Data Acquisition	$2.9
2.8	Near Detector Assembly	$1.7
2.9	Far Detector Assembly	$23.9
2.10	Project Management	$3.6
Construction Subtotal		**$224.7**
PED		$10.3
	Total TEC	**$235.0**
R&D		$11.9
	Total Project Cost	**$246.9**

The project is currently seeking DOE approval for CD-1.

The estimate includes appropriate labor rates, fringes, etc., for all institutions including Fermilab with respective overhead rates applied. Material costs include various burdening rates depending on the nature and size of the procurements. Open Plan is the software tool used to develop the project cost estimate.

The project developed a bottoms-up contingency based on maturity of design using a consistent methodology for Materials and Services (M&S) and labor. The result was a contingency of (approximately) 35 percent with respect to the base cost estimate. The NOνA project has few systems but many repeatable components. In many cases, the project is dealing with known vendors and has obtained solid quotes. There are few parts that use new or unproven technologies. The conventional facilities (CF) WBS element has the lowest overall contingency at 23 percent next to project management at four percent. Less rigor was applied in developing the CF contingency estimate as compared to the methodology applied to other WBS elements. A detailed breakdown of contingency by WBS can be found in Appendix D.

4.2 Comments

The Committee found the cost estimate to be well-advanced for this stage of the project. The TPC range of $197-256 million (AY) is reasonable.

The NOνA location and acquisition plan are not yet finalized—this provides the highest level of uncertainty for the project. The Integrated Project Team should work aggressively to finalize these decisions immediately. These key decisions will help to clarify uncertainties on the cost estimate and schedule (critical path) and should be given the highest priority. Allocation of contingency to the CF WBS should be evaluated with the same rigor as the other elements.

Overall, the NOνA project is made up of a small number of systems and procurements. Areas of cost risk that require attention are:

- Scintillator and PVC—Tied to volatile oil prices.
- WLSF—Single vendor recently increased price to approximately 60 percent from earlier estimates. A quote is now available, but there remains currency and single vendor risks. Work is progress to solicit alternative vendors.
- Site Improvements/Building—Design/Build strategy is proposed to ensure that the science requirements are clearly identified and confirmed with collaboration.
- Integration—Emphasize early prototyping of the Near and Far Detectors to ensure defects (or value engineering) are identified early on.
- Quality Control/Database Management—Many parts repeated up to 20,000 times. Additional staff, testing, and documentation may be required.
- Spares to account for infant mortality (electronics) and breakage/defects to achieve CD-4.

The project is using an effective methodology for contingency. Assessment is reasonable in most areas and should be repeated prior to CD-2, incorporating decisions on the site location, building, and acquisition strategy. The 100 percent contingency assessment on integration labor should be reviewed for accuracy.

The detailed Basis of Estimate (BOE) was not fully documented. Although, it is not necessary for CD-1, a comprehensive BOE (with quotations and detailed estimates) is required for CD-2.

Project Office staff currently have off-project responsibilities that may create a bottleneck in configuration control and management processes. Prior to CD-2, staffing should be reviewed to ensure key configuration and QA staffing needs are adequate.

The Committee concluded that currently the NOνA cost estimate is within the range of costs provided in the draft Project Execution Plan and the range could be used as a basis for requesting CD-1, if supported by an appropriate funding profile.

4.3 Recommendations

1. Reassess contingency on the entire project after finalizing the conventional building acquisition strategy and siting.

2. Use a TPC range of $197-256 million for requesting CD-1 approval.

5. SCHEDULE and FUNDING

5.1 Findings

The integrated resource-loaded cost/schedule estimate for the NOνA project consists of (approximately) 3,500 schedule activities using the scheduling tool Open Plan. The project team presented a schedule range between 45-58 months for the NOνA project with a 25kT detector. The best estimate was 50 months. The project team has also identified a scope range between 25kT and 34kT for a fixed TPC of $247 million (AY). Proposed DOE CD-4, Approve State of Construction, milestones were presented for each Level 2 subsystem.

Sources of forward-funding outside of DOE/SC are being sought, namely from the University of Minnesota; however, to date no source can be considered firm. The NOνA management team is also actively seeking other additional funding sources outside of DOE.

5.2 Comments

The Committee found the 50-month schedule for a 25kT detector to be reasonable at this stage of the project. The schedule will dilate with changes to the mass scope. CD-4 dates and definitions for the project have been proposed at WBS Levels 1 and 2. The proposed DOE cooperative agreement for the building site and construction appears to be on the project critical path. Exact site and acquisition strategy will be needed at CD-2. Environmental and seasonal construction risks should be well defined prior to CD-2.

Major material procurements are a key schedule risk. The project team is to be commended for confirming quotes and delivery dates/quantities to produce a credible schedule. All large procurements appear to be well advanced and delivery schedules tie in well with integration tasks.

The Committee was not provided with FTE estimates or manpower profiles. Clear, supportable estimates on manpower will be needed at CD-2, which should include base program supported physicists. The project team should communicate their resource needs with the laboratory and collaboration management.

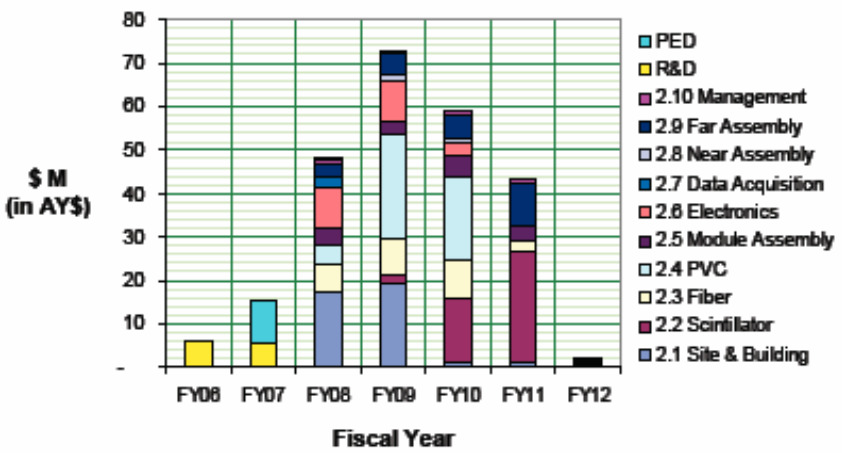
Integration tasks are well developed and under capable management for CD-1. The schedule needs revisiting once the acquisition strategy is finalized. Schedule risks related to

integration and assembly tasks should be well understood prior to CD-2.

A rough "technically-limited" funding profile was derived by the project team from the AY cost and schedule loaded profile. Cumulative planned R&D and PED work in FY 2007 will inundate available funding (assuming this work is fully committed) and will leave no available funding contingency for solving problems or maintaining schedule. The adequacy of R&D/PED funding is also dependent on resolution of the acquisition strategy. The FY 2008 funding assumes construction funds that require CD-2 approval. Once a funding profile is established, the project team should review its resource-loaded schedule to ensure success on NOνA's commitment to DOE.

Table 5-1. NOνA DOE Proposed Funding Estimate (Escalated M$)

AY$ Assumes a Profile From the NOνA Cost & Schedule in Open Plan



5.3 Recommendations

1. Develop FTE resource estimates for the NOνA project (including zero cost physicists) immediately and communicate the project's needs throughout laboratory management and the NOνA collaboration.

2. Recommend approval of CD-1.

6. ENVIRONMENTAL SAFETY and HEALTH

6.1 Findings and Comments

The NOνA ES&H review addressed planning for construction and R&D Integrated Safety Management (ISM). NOνA management and staff vocalized and demonstrated support of ISM functions and principles. The ES&H aspects of NOνA are adequately addressed for this stage of the project.

Since the primary construction activity, the Far Detector Laboratory is planned for a Minnesota site, a primary NOνA project environmental assessment will be conducted to satisfy the Minnesota state rules. The project is required to have an approved Environmental Assessment Worksheet (EAW) for Minnesota, and NOνA holds documentation stating that the University of Minnesota will be responsible for submitting the EAW as the responsible government unit (RGU). The EAW will meet DOE requirements for the Minnesota site. NOνA management anticipated the need for additional environmental assessments for NOνA LS blending activities performed onsite by Fermilab.

NEPA documentation for the construction phase of the project was developed.

The NOνA team drafted a Preliminary Hazard Analysis, (NuMI) Off-Axis ν_e Appearance Experiment Hazard Analysis Document on November 11, 2005. The document is substantial and the team anticipates updating the plan as the project tasks are finalized. For example, if NOνA LS blending activities are performed onsite by Fermilab, then a more complete discussion of blending hazards is warranted. When an epoxy system is selected, the occupational health impact of sensitization to the epoxy components should be included. The confined spaces safety considerations required for the project should also be discussed.

The schedule for completion of ES&H documents before CD-2 is reasonable.

6.2 Recommendations

1. Include ES&H criteria in selection of mineral oil if a “mildly refined” mineral oil is considered.

2. Determine the impact of DOE 10 CFR 851, Worker Safety and Health Program, on the project. The rule codifies, with enforcement, the DOE worker protection program and is effective February 2007.

7. PROCUREMENT

7.1 Findings

The NOνA project procurement activity is estimated at $150 million (approximately 70 percent of the TPC).

There has been significant progress on procurement support for this stage of the project. Contracts are in place for: prototype 16-cell extrusions; 25,000 meters of WLSF; dual sourced mineral oil orders with options valued at $21 million; and wave shifter procurements with options, are ready for award when final technical evaluations are complete.

Project management knowledge of cost drivers, schedule challenges, and technical issues surrounding procurement activity is exemplary and management is aggressively working these challenges in a proactive manner.

NOνA management is involved with DOE in establishing critical milestones and controls for the collaborative agreement to support CF operations.

Import duties and exchange rate information are addressed on significant foreign procurements, but require further refinement.

7.2 Comments

Project management is commended for efforts to obtain formal business prices to support cost estimates on key procurement activity. This reduces cost risks to the project and positions NOνA to provide DOE with credible cost information to support upcoming CD-2 requests.

Procurement personnel are placing prototype and initial orders with cost escalation indexes and options for follow-on quantities.

The project should formalize how potential exchange rate fluctuations in business practices are addressed.

Import duty exemptions may be possible for the significant foreign procurements.

7.3 Recommendations

1. Pursue potential import duty exemptions on major foreign procurement activities in support of NOνA prior to finalizing and placing obligating business documents.

2. Continue to ensure project personnel work closely with procurement personnel to quantify costs on major procurements prior to CD-2 submission.

8. MANAGEMENT

8.1 Findings

The NOνA Collaboration and Project Management team have completed a CDR. The CDR has clearly stated physics requirements, as well as technical solutions that satisfy the physics requirements. Technical alternatives were explored and documented. Significant optimization of the proposed design was completed and is acceptable for the current state of the project.

The NOνA team has estimated the cost range of the project to be $197-256 million (TPC in AY), with a best estimate of $247 million. The estimated schedule range is 45-58 months, with a best estimate of 50 months.

A NOνA Project Management team is in place and functioning well. The documents needed to complete the CD-1 process were identified—most of the documents are complete. The remainder of these documents is in final draft status and require input from the DOE/HEP and the Fermilab Site Office (FSO). The Project Management team has a clear timeline for scheduled CDs (e.g., CD-2) and the related reviews.

The Project Management team developed a detailed R&D plan that includes essential elements required to achieve a project baseline. The personnel (physicists and technical) and other resources required to complete the R&D and design needed to achieve a baseline were identified and are available. There is little contingency in the proposed R&D funding, but the scope of the Integration Prototype Near Detector could be reduced if funds were needed in other areas.

Non-U.S. resources (e.g., from Italy) are being actively sought by NOνA managers and Fermilab management.

8.2 Comments

A firm funding profile for the project has not been established. Close interaction between HEP, NOνA management, and Fermilab management will be required to establish a profile in time to meet CD milestones.

The design and construction of the far assembly building in Minnesota is on the critical path for the project. The DOE NOνA Program Manager and Project Director need to work expeditiously with the NOνA team to establish a mechanism to fund the design and construction of the far assembly building to meet the schedule for CDs and reviews, and the desired project schedule.

Critical input from HEP and DOE/FSO is needed to complete the prerequisite CD-1 documents (Acquisition Strategy and the Preliminary Project Execution Plan). Some coordination with DOE is also required to begin the monthly reporting process in May 2006 Project Assessment and Rating System (PARS). NOνA management should clarify the requirements for Risk Assessment, in particular for CD-2.

The Project Manager recognizes that some additional resources, in the areas of monthly reporting and QA, need to be added to his team in the next few months. The project is actively seeking to add these resources.

8.3 Recommendations

1. CD-1 approval is recommended upon receipt of final documentation.

2. Establish (DOE and NOνA) an overall project funding profile and a mechanism for the design and construction of the far assembly building to proceed to CD-2.

APPENDIX A

CHARGE MEMORANDUM

memorandum

DATE: January 24, 2006

REPLY TO
ATTN OF: SC-25

SUBJECT: Request to Conduct a CD-1 Review of the NOνA Project.

TO: Daniel R. Lehman, Director, SC-1.3

The NuMI Off-Axis Neutrino Appearance (NOνA) Experiment is one of the proposals for the Electron Neutrino Appearance (EνA) Detector. I would like to request that you conduct a CD-1 Review of the NOνA proposal on April 4-6, 2006 at Fermi National Accelerator Laboratory. The purpose of this review is to validate the conceptual design and the cost range, which are needed for Critical Decision 1, Approval of Alternative Selection and Cost Range.

The NOνA project proposes to utilize the existing NuMI beamline and construct two new detectors optimized to detect electron neutrino interactions in order to observe the oscillation of muon neutrinos into the electron neutrinos and measure the parameters of that oscillation. One detector would be located on the Fermilab site and one would be approximately 800 kilometers away in a site to be determined in northern Minnesota.

In performance of a general assessment of progress, current status, and the identification of potential issues, the committee should address the following specific items:

1. Does the conceptual design satisfy the performance requirements?
2. Does the conceptual design report and supporting documentation adequately justify the stated cost range and project duration?
3. Does the proposed project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?
4. Are ES&H aspects being properly addressed and are future plans sufficient given the projects current stage of development?
5. Is the documentation required by DOE O 413.3 in order and ready for Approval of CD-1?

Michael Procario is the program manager for the EνA Detector Project in this office and will serve as the Office of High Energy Physics (OHEP) contact person for this review.

We appreciate your assistance in this matter. As you know, these reviews plan an important role in our program. I look forward to receiving your Committee's report. You are asked to submit a formal report to OHEP within in 60 days of the review.

/signed/

Robin Staffin
Associate Director
Office of High Energy Physics

cc: Ray Orbach, SC-1
James Decker, SC-2
Joanna Livengood, SC-FSO
Pier Oddone, FNAL
Aesook Byon-Wagner, SC-25

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the NOνA Experiment at Fermilab

REVIEW COMMITTEE PARTICIPANTS

Daniel R. Lehman, Chairman (DOE)

SC 1

Scintillator

* Bill Louis, LANL
Richard Hahn, BNL

SC 2

Mechanical and Assembly

* Bill Wisniewski, SLAC
Steve Kane, BNL
Martin Nordby, SLAC

SC 3

Trigger and Data Acquisition

* Klaus Honscheid, OSU
Gunther Haller, SLAC

SC 4

Civil Construction

* Jack Stellern, ORNL
Marty Fallier, BNL

SC 5

Cost, Schedule, and Funding

* Mark Reichanadter, SLAC
Rick Korynta, TJNAF
Steve Tkaczyk, DOE/SC

SC 6

Management

* Murdock Gilchriese, LBNL
Randy Ogle, ORNL
Barry Miller, Consultant
[Mark Reichanadter, SLAC]

Observers

Robin Staffin, SC-20
Aesook Byon-Wagner, SC-20
Michael Procario, SC-20
Steve Webster, DOE/FSO
Ronald Lutha, DOE/FSO
Joanna Livengood, DOE/FSO

LEGEND

SC Subcommittee
* Chairperson
[ ] Part-time Subcom. Member

Count: 17 (excluding observers)

APPENDIX C

REVIEW AGENDA

Department of Energy Review of the
NOνA Experiment at Fermilab

AGENDA

Tuesday. April 4, 2006—Wilson Hall Bldg.—Comitium

8:00 am	DOE Executive Session	D. Lehman
9:00 am	Welcome and Laboratory Overview—**One West**	P. Oddone
9:10 am	Scientific Performance Requirements	G. Feldman/or M. Messier
9:25 am	Project Overview	J. Cooper
10:10 am	**Break**	
10:40 am	Project Cost Drivers	R. Ray/R. Cibic
10:55 am	Site and Building	S. Dixon
11:20 am	Scintillator	S. Mufson
11:50 am	Fiber	C. Bromberg
12:05 pm	**Lunch**	
1:05 pm	PVC and Extrusions	R. Talaga
1:25 pm	Extrusion Modules	K. Heller
1:40 pm	Electronics and DAQ	L. Mualem
2:10 pm	Near/Far Detector Assembly	D.Ayres
2:40 pm	Cost and Schedule Range	J. Cooper
2:55 pm	Cost and Schedule Methodology	W. Freeman
3:10 pm	**Break**	
3:25 pm	Subcommittee Breakout Sessions	

- Site and Building—**Blackhole**
- Commodities—Scintillator, Fiber, and PVC—**One North**
- Extrusion Module Production—**Snakepit**
- Electronics and DAQ—**Racetrack**
- Far and Near Detector Assembly—**One East**

5:00 pm	DOE Executive Session—**Comitium**	D. Lehman
6:00 pm	Adjourn	

Wednesday, April 5, 2006

8:00 am Subcommittee Breakout Sessions

- Site and Building—**Blackhole**
- Commodities—Scintillator, Fiber, and PVC—**One North**
- Extrusion Module Production—**Snakepit**
- Electronics and DAQ—**Racetrack**
- Far and Near Detector Assembly—**One East**
- Management, Cost and Schedule—**Comitium**

10:00 am **Break**

10:15 am Subcommittee Breakout Sessions, Con't

12:00 pm **Lunch**

1:00 pm Subcommittee Breakout/Working Session

3:00 pm DOE Full Committee Executive Session—**Comitium** .....D. Lehman

6:00 pm Adjourn

Thursday, April 6, 2006

8:00 am Subcommittee Working Sessions—**1 North**

10:00 am DOE Full Committee Executive Session Dry Run—**1 North**.....D. Lehman

12:00 pm Working Lunch

2:00 pm DOE Summary and Closeout—**One West** .....D. Lehman

3:00 pm Adjourn

APPENDIX D

CONTINGENCY TABLE

NOνA Contingency Table
April 4-6, 2006

	WBS	Items	Project Estimate AY $K				
			To Date Cost	To Go Cost	Contingency		Total
					$	%	
TEC	2.1	Far Detector Site and Building	$ -	$ 32,199.8	$ 7,454.8	23%	$ 39,654.6
	2.2	Liquid Scintillator	$ -	$ 32,016.1	$ 9,690.1	30%	$ 41,706.2
	2.3	Wave-Length-Shifting Fiber	$ -	$ 20,466.3	$ 5,730.4	28%	$ 26,196.7
	2.4	PVC Extrusions	$ -	$ 34,196.0	$ 13,653.0	40%	$ 47,849.0
	2.5	PVC Modules	$ -	$ 9,848.8	$ 5,518.8	56%	$ 15,367.6
	2.6	Electronics Production	$ -	$ 14,824.2	$ 6,993.4	47%	$ 21,817.6
	2.7	Data Acquisition System	$ -	$ 2,352.9	$ 569.3	24%	$ 2,922.1
	2.8	Near Detector Assembly	$ -	$ 835.1	$ 821.7	98%	$ 1,656.8
	2.9	Far Detector Assembly	$ -	$ 12,803.1	$ 11,145.4	87%	$ 23,948.5
	2.10	Project Management	$ -	$ 3,464.7	$ 119.5	3%	$ 3,584.1
		Construction	**$ -**	**$ 163,006.9**	**$ 61,696.3**	**38%**	**$ 224,703.3**
	PED Funded		$ -	$ 8,491.2	$ 1,808.8	21%	$ 10,300.0
		Total TEC:	**$ -**	**$ 171,498.1**	**$ 63,505.1**	**37%**	**$ 235,003.2**
OPC	**R&D**		$ 1,043.2	$ 11,690.6	$ 186.3	2%	$ 11,877.0
		Total OPC:	**$ 1,043.2**	**$ 11,690.6**	**$ 186.3**	**2%**	**$ 11,877.0**
		TPC:	**$ 1,043.2**	**$ 183,188.8**	**$ 63,691.4**	**35%**	**$ 246,880.2**