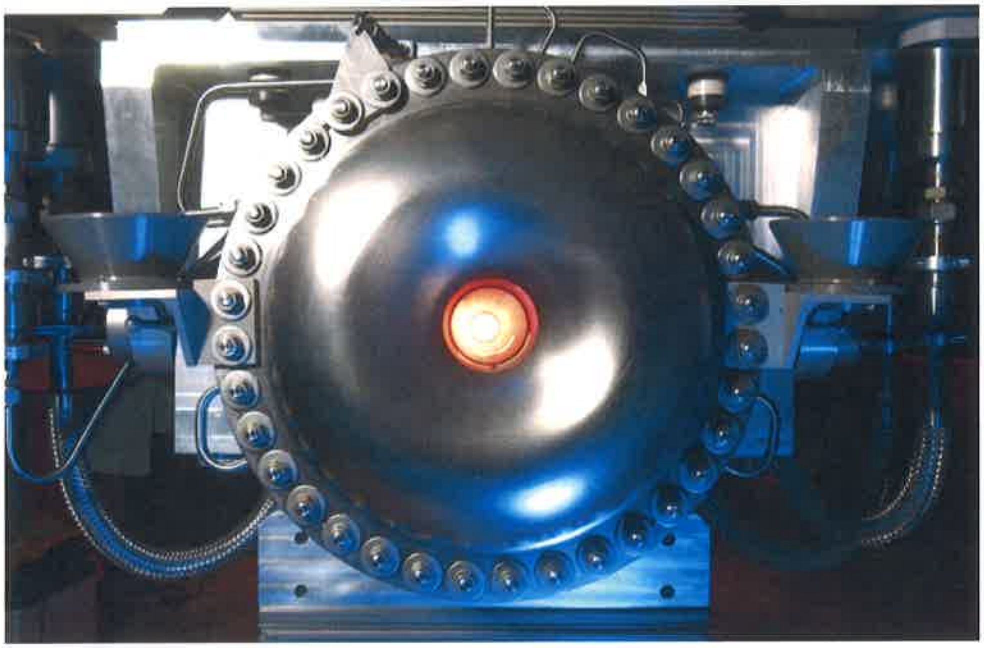
Fermi National Accelerator Laboratory

Fermilab

NuMI Target Systems AIP

Project Plan

December 2018



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The Project Plan (PP) describes the management, control systems, and procedures used by Fermi National Accelerator Laboratory (Fermilab) to meet the technical, cost, and schedule objectives of this project. This controlling document establishes the basis against which progress will be measured.

The Project Plan is to be viewed as a "living document," and as such, will be revised when necessary. The Project Manager is authorized to approve non-substantive changes to the PP (e.g., name changes to the positions cited in the PP), but will inform the DOE Project Director via e-mail of such changes. Baseline changes will require approval by the Department of Energy's (DOE) Fermi Area Office.

NuMI Target Systems AIP Project Management Plan
Change Log

Revision No.	Pages Affected	Effective Date
Initial Version	Entire document	October 23, 2017
1	Reduced scope	November 13, 2018
2	Change TPC from $5.9M to $5.6M while waiting for decision from DOE	December 7, 2018
3	p19 missed changing a 5.9 to 5.6	December 12, 2018

Contents

1 Submittal Page

Submitted, Reviewed, and Approved by:

12/12/18

Michael Lindgren Date
Accelerator Division Head

12/12/18

Mary Convery Date
AIP Coordinator

12-12-18

Robert Zwaska Date
Project Director

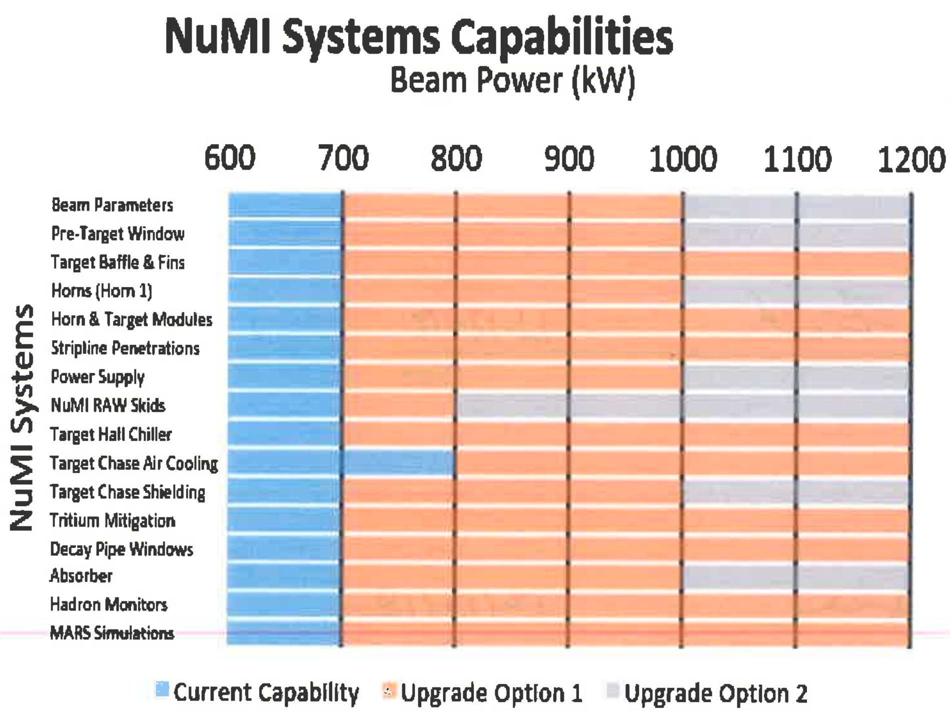
12/12/18

Yun He Date
Project Manager

2 Project Objectives

The NuMI Target Systems AIP provides upgrades to various beamline components and associated support systems needed to make the target station robust at beam powers up to 1 MW. Most of these systems were designed for beam powers of 700 kW and prevent increases in beam power which are already attainable.

The results of an analysis of capabilities of the NuMI target systems as a function of beam power are shown in the following chart. All the systems shown require upgrades to be robust up to 1 MW, and most require upgrades to go beyond 700 kW. Some systems would require a second level of upgrade to go beyond 1 MW; we will pursue the minimum upgrade option to allow running at 1 MW.



The estimated Total Project Cost (TPC) is $5.6M.

3 Project Scope

The scope of the NuMI Target Systems AIP is to improve and replace components or monitoring instrumentation of the Target Hall, Decay Pipe, Absorber Systems, and associated support systems. These objectives will enhance beam delivery, while maintaining reliability, eliminating obsolescence issues, and ensuring the useful lifetime of the NuMI Target Facility, until repurposing or decommissioning. In detail:

- Beam Acceptance Capabilities
    - Ability to accept 6.5E13 protons per spill (from 4.9E13).
    - Maximum beam energy of 120 GeV, with a cycle time of 1.2s (from 1.33s).
    - Maximum beam power to target of 1 MW.
- Reliability
    - Eliminate known major reliability issues.
    - Maintain component lifetime requirements.
    - Maintain 85% availability for High Energy Physics at full proton delivery.
- Obsolescence
    - Eliminate known major obsolescence issues.
- Lifetime
    - Minimally through 2025.

The proton supply to NuMI is expected to increase incrementally to 6.5E13 protons per spill, providing the NOvA experiment a greater opportunity to maximize the potential of the target facility. This increased proton supply is expected to exceed the current engineering limits for several beamline devices or their associated support systems. Therefore, each system must be reassessed and redesigned where warranted to accept a total integrated beam power up to 1MW.

Operating temperatures and stresses for the Pre-Target Window, Target Fins, and Horn 1 Stripline are such that further increases in beam power without a corresponding increase in beam spot size and / or cooling will likely cause accelerated failure. Additionally, life of facility components such as the Decay Pipe, Decay Pipe Windows, and Absorber have set limits which must be re-assessed with new beam parameters. From these reassessments, the goal is to maintain the original design life as set forth in the NOvA requirements listing for replaceable, as well as permanent, components.

In accordance with best engineering practices and guidelines from the Fermilab Engineering Manual, the redesigns and corresponding retrofitting efforts for beamline devices and support systems will be performed while integrating the principle of ALARA. These design and replacement efforts are critical to achieving 1MW beam power to target, and retrofitting efforts in particular, will involve numerous work plans or procedures to minimize accumulated dose to technicians and contamination control for the entirety of the target facility.

Numerous systems within the fifteen-year-old target facility have known reliability and obsolescence issues (e.g. unavailable parts). If these issues are not addressed, the target facility will have more frequent and longer periods of downtime. The failure rate is expected to increase with time and the planned increased repetition rate and beam power. These systems will be replaced or modified as needed with a goal of eliminating obsolescence issues and maintaining NuMI target facility availability at historical levels, even with the higher repetition rate and throughput.

The minimum lifetime of the target facility is based upon conservative estimations for civil structures, in addition to specific degradation rates of the geomembrane barrier and similar radiation / tritium migration control structures. For planning purposes, we consider 2028 to be the latest date 120 GeV protons are likely to be available from the main injector, depending on the project schedule and staging status of the Long Baseline Neutrino Facility.

The NuMI Target Systems AIP will include the following scope.

1. Pre-target beam window, target baffle, and target core

   The pre-target window, made of beryllium, is the interface juncture between the primary beamline and the target chase. The existing flat-faced window was designed for 400 kW operation and is not expected to be robust at beam powers above 750 kW. A previous attempt to design a domed window to help better distribute stress at 700 kW failed due to fabrication techniques used from the vendor related to the decreased effective braze land area.

   - Perform mechanical and thermal analyses to optimize beam spot size and window curvature with respect to temperatures and stresses at beam powers up to 1 MW.
   - Modify window fabrication techniques to improve robustness of the braze joint and stress distribution.
   - Fabricate new window.

   The target core, consisting of graphite and beryllium fins, is the component which is the most susceptible to thermal shock and stress from increased intensity. The target baffle for NOvA was twice redesigned to accept the higher beam power associated with 700kW operation. The first redesign from the NuMI low-energy style was an increase in bore hole diameter and cooling pin count, followed by a subsequent redesign to increase cooling fin surface area and simplify component count and assembly time. This design is also sized to accommodate the current beam spot size of ~1.3mm, and thus the clearance should be subsequently increased for beam spot size growth past 1.5mm. This enlargement requires a thermal and structural analysis to ensure maximum aluminum temperatures do not undo the press-fit final assembly.

- Redesign the core and baffle to accommodate larger fins for the larger beam spot size needed for beam powers beyond 700 kW.
- Fabricate and install new target core and baffle.

2. Horn 1, Bus cooling, Modules

Horn 1 inner conductor temperatures and stresses are of vital concern. The original horn designed for 700 kW failed after about 27 million pulses (1.5 years) instead of the 100M-pulse design lifetime due to an electrical bus (stripline) breakage towards the connection to the main conductor; the cause was eventually determined to be rooted in excessive displacement due to vibration. A redesigned stripline that better addresses temperature and fatigue stress concerns is currently being fabricated and will be connected to an existing 700 kW design horn. Going beyond 700 kW beam power will require further modifications.

- Perform studies to verify expected operating temperatures of the horn inner conductor and other horn and stripline components, with redesign, fabrication, and installation of a new stripline expected.

The electrical bus penetration on the downstream end of the modules, commonly referred to as the stripline block, is of concern due to current operating temperatures. This shield block, and its internal bus, have the same contributing factors to heat load as the horns themselves: energy deposition from beam heating, as well as joule heating from the current pulse. Prior analysis completed for 700-kW operation has the bottom end of the stripline block operating at roughly the set engineering temperature limit for aluminum, around 100°C. Further increases in beam power should ideally be matched by new air diverter systems to provide cooling to this critical juncture in the bus, as failure could potentially result in the replacement of both Horn 1 and its stripline block.

- Design, fabricate, and install a dedicated cooling system for Horn 1 current supply bus (stripline), routed through the shielding penetration.

The target and horn modules are no longer capable of completing the full range of motion they were intended to have. Original construction of module components was primarily steel based, and used some common coatings at the time for corrosion resistance. Due to the atmosphere in the target chase and the overall age of the components, none of the original coatings remain, and the structures have generally corroded to the point where kinetic interfaces are frozen. The target module transverse drives are frozen, the horn 1 transverse drives are also frozen, and the vertical drives must be manually operated due to stiffness in the members and poor motor controller wiring due to radiation damage. Problems with the vertical module positioning drives became apparent during the 2016 summer shutdown, as positional accuracy was lost due to deteriorated bushings, costing an additional 2 weeks of downtime to repair. Further corrosion is expected, and if vertical drive mechanisms begin to freeze, there will be no recourse for correcting the target or horn position in the chase to meet either the on-axis or off-axis tolerances required by the experiments. As the modules are highly activated, they would likely require some significant cool down period to be able to diagnose, fix, and/or retrofit.

- Rebuild module positioning drives and mechanisms with corrosion resistant materials.
- Replace monitoring electronics and survey monuments.

3. Air, water, and radiation protection

The radioactive water (RAW) system provides cooling for the target and horns. RAW systems present in the MI-65 underground RAW room, as well as further downstream in the absorber hall, are capable of higher beam power operation to some extent. As these systems function somewhat linearly with regards to beam power sent to NuMI, the feedback and readouts can be monitored to understand high intensity running conditions. Every system was previously reviewed, and upgraded were necessary to safely reach 700 kW. A secondary system review is needed for beam powers up to 1 MW, followed by focused upgrades or operational changes to the skids. The heat exchangers for the horns and targets are already sized to take a massive increase in thermal load from the beam energy deposition. The remaining limitations of the skids and system as a whole are on the supply pumps and return piping. The supply pumps are at their operational limit, splitting water into two circuits: cooling to components and a DI clean-up loop. Further cooling flow to components cannot be achieved, as the corresponding decrease in flow to the DI clean-up loop will raise the conductivity of the water past the alarm limits, creating a potential short path inside the horns. The secondary limitation is that the return system is not sized to remove the resultant volume of water from a flow increase.

Other minor issues with RAW systems that will be addressed for reliable operation are pressure, flow, and temperature sensor locations and designs. Existing sensors have a relatively short life expectancy due to both the proximity to the irradiated water, as well as the specific construction of the sensing element from each respective vendor. Failure of the sensors will trip the alarms or give inaccurate data, potentially leading to a subsequent failure of a major beamline component.

- Upgrade RAW pumps and redesign piping to increase flow.
- Replace pressure, flow, and temperature sensors whose lifetime is shortened by exposure to radiation.

The target chase air handling cooling loop removes heat from the target chase and dehumidification systems. The main air handling system in the NuMI target hall is the primary recirculation system for the chase air. This system is powered by a 100hp centrifugal fan which provides cooling air for all beamline components, as well as the shielding steel and concrete which makeup the chase bathtub. This air is routed past the heated beamline structures, through a filter bank, and then drawn past the cooling coils prior to being re-pressurized by the fan to complete the loop.

The primary system needing attention is the variable frequency motor drive for the 100hp chase fan, which is an older unit with minimal spare parts support. This unit operates without issue 99.9% of the time, but a cooling fan failure, which has twice occurred, will result in a 3-week downtime to repair the cooling fan for which no spare parts exist.

Several air monitoring devices are also present in the target chase air handling system to monitor filter bank pressures and temperatures. Most are from the original commissioning of NuMI and need replacement. Failure of pressure sensors will prevent beam delivery and take on the order of days to fix. Several instruments which indicate air system integrity are no longer available.

- Upgrade instrumentation in the target chase air handling system that monitors filter bank pressures and temperatures.

The target chase chiller unit consists of eight compressors and heat exchangers tied into a single system. These eight compressor modules exchange heat from the target chase air handling cooling loop, which removes heat from the target chase and dehumidification systems. Compressors of this type are rated for a constant duty cycle, however do have a set service life advertised by the manufacturer. Strenuous operation from our environment, most notably precipitate formation in the cooling water, has degraded coil performance for some time. Long term operation and the degrading characteristics of the coolant have left one of the eight modules completely dead, as a breach occurred between the heat exchanger and its corresponding compressor process loop. The remaining seven compressors are generally operating near 100% capacity. Expansion of the coil capacity in the existing air system is possible but will require a doubling in cooling water flow to the bank to maximize efficiency.

Failure to maintain chase air supply temperature greatly impacts nearly all components in the beamline, and raising the operating temperature will further expose electrical bus in the chase to higher operating temperatures, thus decreasing the life expectancy.

- Upgrade pumps and add 3 cooling coils to the target chase cooling circuit, which exchanges heat from the target chase air handling loop to the Central Utility Building.

Current shielding in the target hall and decay pipe, from an omnidirectional standpoint, is acceptable for limiting prompt radiation dose or subsequent activation of surrounding ground water and rock. The limitation arises with regards to prompt dose in support room areas such as the room used for de-ionizing (DI) water, the power supply room, and the shaft area, which must be accessible during beam operations to minimize downtime needed for maintenance. The cause for this prompt dose is from the RAW room where the "shine" from the radioactive water makes its way over the shield walls into the DI room, and then through the doors that separate each support area.

Target chase shielding protects personnel working on components during maintenance and changeout activities of components such as targets, horns, primary beam windows, and beamline components. Unless shielding is added, increases in residual radiation due to higher beam power will significantly increase the cool-down time needed before work can occur.

- Add shielding to the RAW room and target chase.

Tritium yields and activation of air and beam equipment must be re-evaluated for assessment of the radiation shielding. There is a significant uncertainty when predicting the tritium yield in the beam enclosure. Tritium is chemically active; therefore, most tritium is turned into water (HTO), and is accumulated by a dehumidifier. This tritium is captured and disposed of in a controlled manner, however, some amount of tritium evaporates from the surfaces of a solid material, such as the steel or concrete shielding present in the target chase. When the beam power goes up, the tritium yield is exponentially increased because a great amount of accumulated tritium is released. Some tritium is then taken through the under-drain system, into the sumps, where it's then brought to the surface, finding its way into the ICW ponds. Extrapolation from past observed tritium yield suggests that the Tritium level is still acceptable and can be captured with the present dehumidification system, however, studies will be performed and changes made as necessary.

- Retrofit or expand existing tritium mitigation systems.

4. Decay pipe and window assessment

The water-cooled decay pipe is a 2m diameter, 675m long steel tube, with sealed beam entrance and exit windows at both ends of the pipe. The decay pipe was filled with helium gas after discoloration and suspected corrosion was found on the window at beam spot center around 2007.

Although most likely a direct cause of operating temperature, the true mechanism for discoloration is unknown (heat or corrosion or both). It is most likely that this is oxidized aluminum, caused by heating due to energy deposition and an abundant source of moisture during early operation. Service life expectancy of the window is unknown due to inability to closely monitor material condition and surface defect formation. Unfortunately, there are limited invasive methods for further determining window health, as even the most gentle or direct still have some risk associated with them.

If this window failed without a replacement plan and spare window ready to go, the downtime could be as much as two years, and could prematurely trigger the end of the NuMI program.

- As risk mitigation, develop a window replacement procedure and fabricate a spare window.

5. Hadron absorber instrumentation and beam monitoring

The Hadron Monitors function as an ionization chamber based beam profile monitor, which is installed downstream of the target. Its nomenclature originates from the primary particle in the monitor, i.e., a hadron, and detection of the hadrons is accomplished by suppling helium gas as an ionization media to the chamber. The first monitor is located after the decay pipe downstream window to align the primary proton beam on the target.

Construction of the monitor must be radiation-hard since the entire detector body is exposed to extremely intense radiation, which is one of the major issues with monitor longevity. Other monitors, such as the muon monitor, are located downstream of the absorber to measure muon profiles, which do not have a radiation exposure issue due to the rock shielding between the two chambers.

Primary issues with the hadron monitor are electrically based, such as the insulator resistivity of an electrical feedthrough and coaxial cable had dropped at some point, promoting a current leakage. Visual inspection of the chamber after several beam runs would appear to indicate that metal plating on the ceramic insulator and the insulator near the gas exhaust port exhibits discoloration. To this date there is not an accurate assessment of how long the hadron monitors will function due to unknown corrosion issues and general electronic component degradation. Best estimates are that the monitors have a roughly 3-year life expectancy.

There are two approaches for high intensity operation upgrades. One option is a redesign of the existing hadron monitor, incorporating a more suitable radiation resistant insulator for the feed through connection. In addition, avoidance of the discoloration and possible corrosion caused by ionization gas impurities could be rectified using a gas purifier after the gas regulation system. Lastly, a bubbler (gas trap) can be retrofitted on the exhaust gas line to block backward gas injection into the chamber.

A second option for high intensity operation would be the application of alternate beam profile monitor technology. There are two types of monitors that hold promise for this application. The first is a secondary electron emission monitor (SEM), which has been investigated. Because the structure is very similar to the ionization chamber, similar radiation issues should be addressed in the SEM regarding electrical isolation and gas purity. A second option is using a multi-cell gas-filled RF cavity. The basic theory behind its operation is that the gas permittivity is proportionally changed by the amount of beam-induced gas plasma in the cavity. The permittivity shift for each RF cavity is then observed by measuring the RF modulation to reconstruct the beam profile. R&D of these techniques have been in progress and are ongoing.

- Design, assemble, and install new radiation-hard Hadron Monitors.

The hadron beam absorber is located downstream of the decay pipe and the hadron monitor, and has a core consisting of aluminum and steel blocks, which are cooled by the RAW skids in the adjacent absorber hall enclosure area. The aluminum and steel core is then surrounded by a series of stacked concrete blocks. The main function of the absorber is to eliminate the residual high-energy charged particles in the secondary flux, apart from muons, which travel onward to the muon alcoves for detection by separate monitors. Since a large portion of the beam energy is deposited in the absorber core, removing that heat is critical to ensuring the aluminum does not reach ~150°C, or fatigue failure due to creep becomes a real concern.

Previous evaluations show that the absorber can endure up to 1.2 MW beam operation by ramping up cooling water flow and decreasing RAW supply temperatures as previously described in the RAW section. Instrumentation should be added to monitor temperatures.

- Design, procure, and install instrumentation to monitor temperatures, etc, of the beam absorber.

4 Project Organizational Structure

DOE Management

The Fermi Site Office administers the M&O contract with FRA for operations of Fermilab and exercises oversight of Fermilab. The Fermi Site Office Manager, Michael J. Weis, has been delegated responsibility and authority for execution of the project. The specific responsibilities of the Fermi Site Office manager are:

- Supervision of DOE Project Director and Fermi Site Office staff;
- Review and approval of documents as required by federal regulations or departmental orders or notices;
- Approval of Fermilab subcontract actions, within the authority delegated to Fermi Site Office;

Funds will be made available to DOE for the project on an annual basis following passage of legislation in the U.S. Congress.

The Fermi Site Office Manager has delegated authority and responsibility for management and direction of the project to the DOE Project Director, Paul Philp. The specific responsibilities of the DOE Project Director include:

- Review of this PP and changes thereto
- Measurement of performance against established goals including technical performance, cost levels, and schedule milestones
- Making any necessary changes or as it pertains to taking corrective actions within the appropriate thresholds established in this PP
- Overseeing Fermilab's management of installation activities
- Monitoring project progress via reports prepared by the Project Manager.

The DOE has delegated the responsibility for this project to Fermilab.

Fermilab Management

This project will be managed based on the guidance provided in DOE Manual 413.3-1b. Other DOE Orders and Manuals, especially regarding design, engineering, contingency, and indirect costs have been used to determine the basis for estimating costs and establishing baselines. This identification, implementation, and compliance with other relevant Orders, manuals, and requirements are the responsibility of the project team.

Figure 1 identifies the organizational structure that will be responsible for procurement and installation of this project.

As with all activities at Fermilab, the Directorate is at the highest level of responsibility. Michael Lindgren, the Fermilab Accelerator Division Head, is the Project Sponsor championing the project. The Project Sponsor establishes and approves the mission need and allocates the funds from the Fermilab budget.

Procurement, installation, cost, and schedule for this project are the responsibility of the Accelerator Division (AD) which will manage the work associated with this project, as well as accept line management responsibility for safety.

The Project Sponsor has designated Mary Convery of the Accelerator Division as the AIP Program Coordinator (Program Coordinator) and Robert Zwaska of the Accelerator Division as the NuMI Target Systems Project Director (Project Director). The Program Coordinator and Project Director are key stakeholders that have accepted the scope of work as described within this project's Project Plan. The Program Coordinator will initiate all scope changes and shall secure any additional funding authority as defined by the Fermilab Project manager and coordinate interaction with other PIP-I+ projects.

Fermilab has designated Yun He of the Accelerator Division's Target Systems Department as Project Manager and Martin Murphy as Deputy Project Manager. The Fermilab Project Manager will utilize the resources of the Accelerator Division as appropriate for design, construction, installation, and testing coordination.

All stakeholders are considered to be organizational project assets and are considered invaluable during the planning and execution of the project. The Program Coordinator and project manager will identify those key stakeholders and obtain the relevant inputs critical to the project's success.

Prospective users, landlord ES&H personnel, and building managers are always key stakeholders that are included in the process.

ES&H Management

The ESH&Q Section, with Eric McHugh as the Accelerator Division Safety Officer, has the responsibility for providing Environmental, Safety, and Health coordination and oversight of ES&H throughout the project. As with all Fermilab projects, attention to ES&H concerns will be part of the project management and Integrated Safety Management (ISM) will be incorporated into all processes. Line management responsibility for ES&H will be maintained on this project. Safe coordination of installation activities will be accomplished through the Project Manager, Project ES&H Coordinator, Project Engineer, Target Systems Installation Coordinator, and Task Manager. During installation, the Subcontractors, T&M Crafts, and all Fermilab personnel will utilize Project Hazard Analyzes (PHA) to plan all work and mitigate hazards. The Project Manager and Project ES&H Coordinator will audit compliance with all applicable ES&H requirements.

The project has been found to comply with the NEPA Categorical Exclusion B3.6 DOE/EA-1570.

Organizational Chart

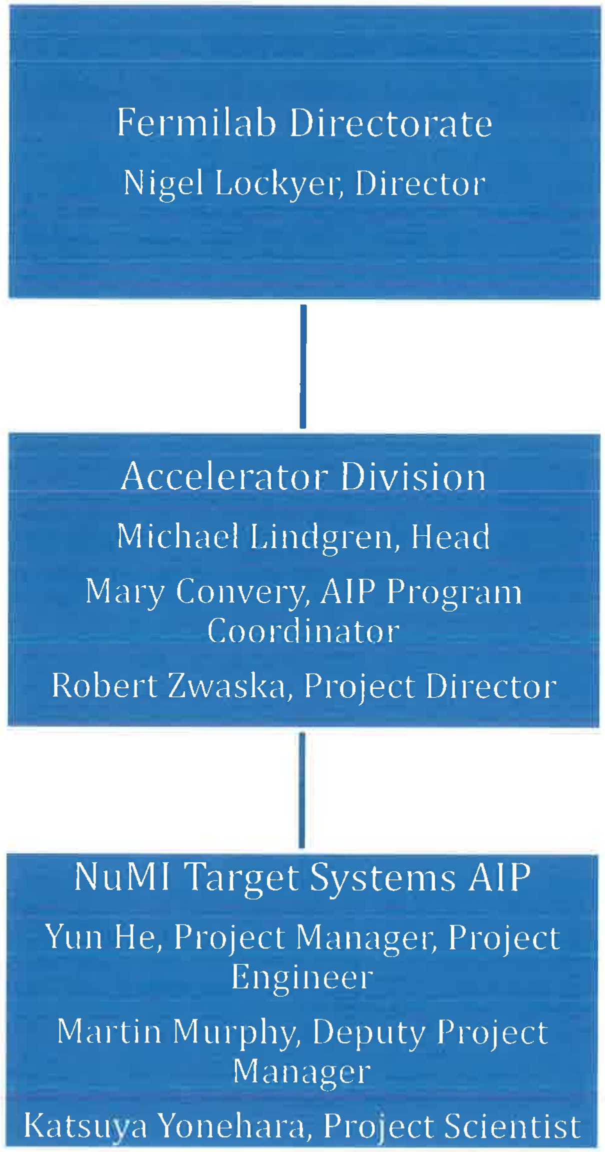


Figure 1: NuMI Target Systems AIP organizational structure.

5 Resource Requirements

Funding

This project is an Accelerator Improvement Project (AIP) with a Total Project Cost (TPC) of $5,600,000.

Personnel

Fermilab Divisions and Sections will be responsible for assigning the responsibilities of individuals within the project organization. The Project Engineer will be responsible for coordinating within the Accelerator Division and other divisions to obtain the appropriate technicians and project support personnel. The Installation Coordinator will coordinate with the Fermilab Time and Materials office to arrange all necessary craft support.

6 Project Baseline

The Project Baseline identifies the basis for evaluating project performance, including the Work Breakdown Structure, which identifies each component of the project, the Baseline Costs, and Baseline Schedule and Milestones.

Work Breakdown Structure (WBS) Dictionary

Listed below is the breakdown of the WBS for this project. Further breakdown of the WBS may be applied as required for accounting purposes.

WBS	Name
A1901	NuMI Target Systems
A1901.01	Project Management
A1901.02	Target, Baffle, Windows
A1901.03	Horn, Striplines, Modules
A1901.04	Air, Water, Radiation Protection
A1901.05	Decay Pipe Window, Targetry Instrumentation

For accounting purposes, the management reserve of the above listed WBS items will be included in the WBS items. DOE Guide G430.1-1, Chapter 11 was used as guidance in estimating the appropriate management reserve for this project.

For accounting purposes, the indirect costs of the above listed WBS items will be included in the WBS items.

Baseline Project Costs

Listed below are the baseline project costs for this project.

WBS	Name	Fully-loaded Cost	Contingency	TPC
A1901	NuMI Target Systems	$4,360k	$1,540k	$5,600k
A1901.01	Project Management	$684k	$205k	$889k
A1901.02	Window, Baffle, Target	$355k	$133k	$488k
A1901.03	Horns, Modules	$1,133k	$421k	$1,554k
A1901.04	Air, Water, Rad Protection	$1,051k	$345k	$1,375k
A1901.05	Decay Pipe Window	$248k	$161k	$409k
A1901.06	Targetry Instrumentation	$644k	$220k	$864k

Escalation

The baseline estimates have been escalated by task within P6 using the lab standard escalation rates.

The rates utilized for Materials and Service (M&S) are as suggested by the most recent published escalation rates. The escalation rates for Salary with Fringe (SWF, Labor) costs are based on input from the Fermilab Directorate based on their latest understanding of out-year labor costs.

Baseline Project Milestones

The baseline milestones listed below sets forth the major activities essential for the completion of the project. Note that all milestones are tied to funds availability within thirty days of the beginning of each fiscal year. Note that installation milestones tied to accelerator shutdowns are outside the control of this project.

Milestone	Definition	Baseline
Start Project	Directive signed and funding available	Month 0
Horn 1 Final Design	Final design of horn 1 stripline complete	Month 5
Target Fabrication	Target fabrication complete	Month 6
Horn 1 Fabrication	Fabrication of horn 1 stripline complete	Month 15
Horn Stripline, Testing	Horn stripline and air diverter ready to install	Month 16
Hadron Monitor Installation	Hadron monitor installation complete	Month 23
Horn 1 Stripline Installation	Horn 1 stripline installation complete	Month 21
RAW, Target Chase Cooling, Shielding, Tritium Mitigation	RAW, target chase cooling, shielding, and tritium mitigation complete	Month 11
Project Complete	Project closed	Month 26

Obligation Profile

Listed below is the anticipated total Obligation Profile for this project as contained in the Fermilab Project Request Form.

		FY19	FY20	FY21	Total
Labor					
	FTE	4.55	2.20	0.35	7.10
	SWF direct+indirect +escalation	$1,274k	$514k	$108k	$1,896k
	SWF mgt reserve	$465k	$219k	$42k	$726k
	Total	$1,739k	$733k	$150k	$2,622k
M&S					
	M&S base (FY19 $)	$1,573k	$180k	$0k	$1,753k
	M&S direct+indirect +escalation	$1,987k	$232k	$0k	$2,219k
	M&S mgt reserve	$675k	$85k	$0k	$759k
	Total	$2,662k	$317k	$0k	$2,978k
Total					
	Direct+indirect +escalation	$3,261k	$991k	$108k	$4,360k
	Management reserve	$1,140k	$359k	$42k	$1,540k
	Total	$4,400k	$1,050k	$150k	$5,600k

7 Acquisition Execution Plan

The project management, construction management, installation and inspection for this project are being performed in compliance with the applicable DOE Orders, Laboratory Policy and Procedures and in accordance with the Work Breakdown Structure.

Procurement Strategy

Nearly all components required for the NuMI Target Systems AIP will be provided from, or fabricated at, specialized third party machining, welding, or material production facilities. All items will be subject to the Fermilab procurement guidelines, which requires an open bidding process to ensure competitive bids on cost, value, or technical requirements are obtained. Specific components or finished assemblies which will have considerations outside of cost alone are the Horn 1 current supply bus, replacement beam windows, and the redesigned hadron monitor.

These items represent an accumulated cost over $100k each in M&S, and therefore additional attention is warranted for their procurement. Each of the three assemblies listed are built in whole or in part from smaller components, some of which must be obtained through a limited vendor base. Other components are technically challenging to build, and specialized capabilities are required for any company to be invited for bidding. The procurement strategy for these components is to use well-known companies with a history of making identical or near identical items for the lab on prior purchase orders. Efforts will be undertaken to limit cost when feasible in the event a sole company has the ability or desire to submit a bid.

All other specialized fabrication or assembly activities must be completed on site by lab technicians and engineers. These items have been identified, and when broken into sub-assemblies or individual component parts, competitive procurement through standard lab channels is sufficient to meet the cost and schedule requirements of the project.

Engineering, Design, Inspection and Administration

Preliminary Engineering designs were performed in conjunction with the research and development efforts and are not included herein. Engineering Design, Inspection and Administration efforts for the fabrication and installation will consist of Fermilab AD personnel.

A Davis-Bacon determination has been prepared for this project.

8 Project Controls

Cost Control

The baseline budget for each element will be shown on all reports. Costs accrued by these accounts will be reported monthly on a report issued by the Finance Section. The Project Manager will review the report and verify the validity of all cost charges during the reporting period that commitments are correct and that projections of costs can be covered by the baseline budget for each work element.

The Project Manager has the responsibility for the use and commitment of project funds. Any costs or commitments that are made without his signed approval or that of higher Laboratory management may be rejected.

The Project Manager, within authorized limits, will be responsible for the administration of the project's management reserve funds.

The Funding Profile, depicted in Section 6, is based on the current DOE funding profile. This plan reflects the best estimate of funding levels and the baseline schedule. The Funding Profile establishes the planned rate of accrued costs for the life of the project. The Project Manager is responsible for updating, as needed, the project Estimate at Completion (EAC) for each work element to reflect changes in design and construction, and for overall project fiscal management.

Schedule Control

The Baseline Milestones, shown in Section 6 of this report, depict the milestones and their expected achievement dates. The Project Manager shall have the responsibility to monitor and control these tasks within the baseline. The baseline may be revised through the change control process.

Change Control Procedures and Authorities

Changes to the project baseline can occur to the scope, cost, or schedule aspects of the project. Changes at WBS Level 1 and below will be made with the approval of the Project Manager for cost changes up to $100,000 and schedule changes up to 3 months. Cost and schedule changes above these amounts and changes to the scope of the project will require the approvals of the Change Control Board. Any change to the Total Project Cost will require the approval of the Change Control Board and DOE Fermi Site Office. Project change control will be accomplished in accordance with practices listed below.

Change	Approval Required	Change Request Form
In scope ≤$100k or ≤3 months schedule change	Project Manager	Required
In scope >$100k or >3 months schedule change	Control Board	Required
Total Project Cost	Control Board DOE Fermilab Directorate	Required
Change to Project Scope or Schedule	Control Board DOE Fermilab Directorate	Required

The Change Control Board (Control Board) will be comprised of the following named individuals or the designees:

DOE Fermi Site Office	P. Philp (non-voting)
Fermilab AD	M. Lindgren
Program Coordinator	M. Convery
Project Director	R. Zwaska
Project Manager, Chair	Y. He

The Project Manager will act as Chair to the Control Board. The Control Board will consider the change requests promptly and, in cases not requiring additional information or discussion, will respond within two weeks.

9 Design and Construction Principles

Integrated Safety Management

Fermilab subscribes to the philosophy of Integrated Safety Management (ISM), in accordance with Department of Energy Order 413.3b "Program and Project Management for the Acquisition of Capital Assets." Fermilab requires its subcontractors and sub-tier subcontractors to do the same. ISM is a system for performing work safely and in an environmentally responsible manner. The term "integrated" is used to indicate that the Environment, Safety & Health (ES&H) management systems are normal and natural elements of doing work. The intent is to integrate the management of ES&H with the management of the other primary elements of construction: quality, cost, and schedule.

Quality Assurance

All aspects of this project will be periodically reviewed with regard to Quality Assurance issues from design through project completion. This review process will be completed in accordance with the applicable portions of the Director's Policy Manual, Section 10. The following elements will be included in the design and construction effort:

- An identification of staff assigned to this project with clear definition of responsibility levels and limit of authority as well as delineated lines of communication for exchange of information;
- Requirements for control of design criteria and criteria changes and recording of standards and codes used in the development of the criteria;
- Periodic review of design process, drawings and specification to insure compliance with accepted design criteria.

Reliability and Maintainability

Both reliability and future maintenance are considered in the design of all components of Fermilab site. Materials and construction techniques are selected during the design process to provide adequate design life, accessibility, and minimal maintenance.

Risk Management

Sufficient budget and schedule contingency are incorporated into the baseline plan to accommodate known risks. New risks which are identified during the project execution will be discussed at the monthly PMG and appropriate action taken, if necessary with baseline change requests.

10 Reporting and Reviews

The objective of the reporting and review activity is to provide the assemblage and integration of project related cost data, schedule status and performance progress into reports for the monitoring and management of the project.

Reporting

Daily – The Project Manager will hold meetings as necessary to discuss progress and issues.

Quarterly – The Project Manager will review progress and changes in a Quarterly AIP report.

Reviews

Directorate Level Review – If requested, the project team will meet with the Directorate to review the project related cost data, schedule status, and performance progress.

DOE Review – Occasional site visits will be arranged between the Project Manager and DOE Project Director.

PMG – Status will be reported monthly to Fermilab Division Heads and the DOE at Project Management Group meetings.

POG – Status will be reported monthly to the Fermilab Directorate at Project Oversight Group meetings or as requested.