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FESS/Engineering Project No. 6-10-2

Program Plan

PgP

Fermi National Accelerator Laboratory
MUON CAMPUS

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CHANGE LOG

Rev. No.	Date	Change Description	Pages Modified
Rev. 0	05/09/12	Initial Release	
Rev. 1	05/15/12	Incorporated misc. comments	Various
Rev. 2	05/16/12	Revised Org Chart	8
Rev. 3	07/22/13	New AIPs, GPP, program coordinator	8
Rev. 4	07/25/13	Add statement that updated requirements docs will be re-signed when there are changes.	1
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LIST OF ACRONYMS

A/E	Architect/Engineer
AIP	Accelerator Improvement Project
ASHRAE	American Society of Heating, Refrigerating and A/C Engineers
BMPs	Best Management Practices
CM	Construction Manager
DOE	Department of Energy
ES&H	Environment, Safety and Health
FNAL	Fermi National Accelerator Laboratory
FPD	Federal Project Director
FSO	Fermi Site Office
FY	Fiscal Year
GC	General Contractor
GPP	General Plant Project
HV	High Voltage Electrical
HVAC	Heating, Ventilation, and Air Conditioning
ICW	Industrial Cooling Water
IPT	Integrated Project Team
IPgT	Integrated Program Team
LCC	Life Cycle Costs
LEED	Leadership in Energy and Environmental Design
M&O	Management and Operating
MC	Muon Campus
MINOS	Main Injector Neutrino Oscillation Search Experiment
Mu2e	Muon to Electron Conversion Experiment
NEPA	National Environmental Policy Act
NOvA	NuMI Off-axis Neutrino Appearance Experiment
OPC	Other Project Costs
PgP	Program Plan
PP	Project Plan
R&D	Research and Development
SC	Office of Science
SF	Square Feet
SWPPP	Storm Water Pollution Prevention Plan
TBD	To Be Determined
TEC	Total Estimated Cost
TPC	Total Project Cost

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1.0 INTRODUCTION, BACKGROUND AND PROJECT DESCRIPTION

1.1 Introduction

This Program Plan identifies and summarizes the critical information and processes necessary to successfully manage, perform, control, and transition the Muon Campus Projects from initial planning through project close-out. Individual Project Plans will be developed to support approval of the General Plant and Accelerator Improvement Projects and revisions will be documented through the configuration control change process.

1.2 Program Background

Fermilab's Strategic Plan outlines a set of key research objectives that Fermilab plans to pursue into the future. One of these objectives, support of High Energy Physics, is a major driving force behind the project that is the subject of this PgP.

New facilities at Fermilab, the nation's dedicated particle physics laboratory, would provide thousands of scientists from across the United States and around the world with world-class scientific opportunities. In collaboration with the Department of Energy and the particle physics community, Fermilab is pursuing a strategic plan that addresses fundamental questions about the physical laws that govern matter, energy, space and time. Fermilab is advancing plans for the best facilities in the world for the exploration of neutrinos and rare subatomic processes, far beyond current global capabilities.

Certain particle physics experiments require particle beams with incredibly large numbers of particles: the Intensity Frontier. Beginning in 2013, Fermilab's upgraded accelerator complex will create more intense particle beams for experiments such as MINOS, NOvA and MicroBooNE that will explore neutrino interactions. The updated complex will also enable the planned muon experiments, Muon g-2 and Mu2e, that will explore rare sub-atomic processes and make precision measurements.

To establish a base for these future muon experiments the Muon Campus is being developed to house these future experiments.

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1.3 Program Description

1.3.1 General Plant Projects

1.3.1.1 GPP Project 1 – MC-1 Building

This project will construct a general purpose facility for the study of muon interactions. The internal outfitting of the facility will be designed and constructed to accommodate the Muon g-2 Experiment but with consideration to subsequent alteration for future follow-on experiments.

The general building will be comprised of a 13,500 gross square-feet facility. The experimental hall will consist of an 80'x80' high-bay facility with overhead bridge crane and one-story basement area designed to support large loads from accelerator equipment. Equipment access will be from a grade-level loading dock. A one and two-story Service Building will include areas for the installation of computing facilities, power supplies, control/counting room, storage space and building support equipment. A one-story 40'x40' Refrigeration Room will be included to house refrigeration equipment in support of installed experiments on the Muon Campus. It will also include toilet and janitorial services and general space for shop equipment.

Utilities will be tapped from nearby feeders and piping in existing utility corridors, including: electrical, communications, natural gas, industrial cooling water, sanitary sewer, domestic water and chilled water. The proposed site has been examined and is not in any wetlands, defined floodplain, or other protected area.

The facility will be constructed in consideration of construction in support of the future Muon Campus, including future beamline enclosures, refrigeration utilities and the future Mu2e Experiment.

1.3.1.2 GPP Project 2 – MC Beamline Enclosure Conventional Facilities

The MC Beamline Enclosure scope of work will consist of the activities required for the construction of a below-grade, cast-in-place and/or precast concrete enclosure to house the programmatic beamline components that will be required to transport beam from the existing Antiproton Ring into the Mu2e Detector Enclosure and MC-1 Building.

The Beamline Enclosure will be a 10 foot wide by eight 8 foot high concrete enclosure approximately 700 feet long, running from the existing Antiproton Ring enclosure to the Mu2e Detector Enclosure. A shortened stub up section will be constructed to transport beam from the Antiproton Ring enclosure up to the MC-1 Building as well. The beamline enclosure is designed to support 16 feet of earth and concrete shielding to grade.

The interior walls and ceiling of the beamline enclosure will be painted and the exterior will be moisture proofed to provide a safe and dry semi-conditioned space for personnel and equipment. The enclosure will be flanked with underdrain piping that will negate the hydraulic pressure on the walls and roof of the enclosure. The underdrains will be routed to a duplex sump that will discharge water onto grade and away from the enclosure. The walls and ceiling of the enclosure will be fitted with channel inserts to allow for the support of cable trays, cooling water, electrical conduits and fire detection equipment.

Convenience outlets, 120/208VAC, will be provided every sixty feet along the wall on the side of the beamline. Welding outlets, 60 amp/408V, will be provided at 2 locations along the enclosure. In addition to required emergency and exit lighting, light fixtures will be provided to supply a minimum of 20 foot-candles. A percentage of these lights will be on UPS circuits to provide emergency lighting during power failures. The enclosure will be ventilated with neutral, dehumidified air. Fire detection will be via air sampling and line type sensors.

The majority of the construction of the Beamline Enclosure will utilize traditional "open cut and cover" methods in which material is removed from the beamline location, the beamline is constructed and the completed enclosure is covered with the excavated material. This method has been used successfully at Fermilab for the construction of the majority of shielded enclosures on-site. For those areas located adjacent to existing utility crossings, an earth retention system will be used.

<u>1.3.1.3 GPP Project 3 – MC Infrastructure</u>

The MC Infrastructure scope of work will consist of providing cooling water for the A-0 cryo compressors and constructing an addition to the MI-52 Service Building.

A six inch Industrial Cooling Water (ICW) is located along the Main Ring Road and is connected to the system near the B-0 and F-0 Main Ring Stations. The ICW system's original design and purpose was to provide the primary heat rejection to experiments and water for fire protection. Additionally the ICW is used as a supplement to maintain water levels in the Main Injector Ponds. The proposed A-0 compressor cooling design uses the ICW as the primary cooling source and rejects the water and heat to the existing ponds at A-0. The A-0 pond will flow to the RF Pond and via an existing gravity line to the Main Injector Ponds. The ICW piping network has been analyzed for both water pressure and water flow. This analysis includes the ICW on the entire Fermilab site, all supply points and discharge points including the demands to address fire with hydrant flow and automatic sprinkler systems.

The MI-52 Service Building is one of the Main Injector's kicker buildings. A 25 ft by 30 ft addition is required for power supplies to support new kickers planned for Recycler extraction to the P1 line. Utilities to the building such as LCW, ICW, electrical power and communications are all adequate to support the new power supplies. There are ample penetrations between the existing service building and the Main Injector enclosure for the additional cabling that is required.

1.3.2 Accelerator Improvement Projects

1.3.2.1 AIP Project 4 – MC Cryo Plant

The MC Cryo Plant AIP will relocate and install three modified satellite refrigerators to support operations of the Muon Campus cryogenic components. Each refrigerator package is comprised of a heat exchanger train, two reciprocating expanders and associated instrumentation and controls, and is capable of producing a maximum of 600W@4.5K.

Two new cryogenic distribution systems will be built to interconnect the refrigerators to the two initial experiments. The cryogenic distribution system includes refrigerator valve boxes, vacuum jacketed cryogenic transfer lines, and bayonet cans.

Helium and nitrogen inventory systems will be added. Three 30,000 gallon Tevatron gaseous helium storage tanks will be relocated from their current location between A3 and A4 to the new Muon Campus refrigerator building, which is part of the MC-1 Building as described in section 1.3.1.1. Furthermore, one of the CHL nitrogen dewars will be moved to the new refrigerator area, as well. Four Tevatron helium screw compressors located at F0 will be made to support the Muon campus refrigerators. A new suction and discharge header will have to be installed to connect F0 compressors and Muon campus refrigerators.

Local controls for the refrigerators and distribution systems will be developed, with an interface to the existing Fermilab ACNET control system.

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1.3.2.2 AIP Project 5 – MC Recycler RF

The Recycler RF project will assemble and install seven 2.5 MHz cavities and associated RF amplifiers, controls, cooling, and support hardware within the Recycler. Two extra "bare" 2.5 MHz cavities will be assembled.

1.3.2.3 AIP Project 6 – MC Beam Transport

The Beam Transport project will provide an extraction system (Lambertson and kicker magnets) from the Recycler, the beamline connection from the Recycler to the P1 line, aperture improvements needed to transport the 8 GeV proton beam efficiently in the P1, P2 and M1 beamlines, as well as instrumentation, controls and electrical infrastructure upgrades in those beamlines. The modifications to the upstream M3 (8-GeV proton) line required to optically match to the downstream portion which supports both 8-GeV protons and 3.1-GeV secondary beam will be also provided.

1.3.2.4 AIP Project 7 – MC Delivery Ring

The Delivery Ring project will convert the former antiproton Debuncher into a Delivery Ring for beam to the muon campus. In the Delivery Ring, an injection kicker and septum magnet will be added to allow direct injection of 8 GeV protons, or 3.1 GeV muons from the new M3 beam. Collider equipment that is no longer necessary will be removed to maximize the aperture. An abort system will be installed in the 50 straight section. This system will serve as a standard proton abort for Mu2e, as well as provide the ability to remove unwanted protons from the muon beam circling the Delivery Ring. Instrumentation will be upgraded to be compatible with the beam structure specified by future muon experiments. Upgrades to the electrical panels and services buildings will be implemented to better serve the future power supply systems needed for muon operation. There are some power supplies that will be upgraded as a result of their age and difficulty in maintaining.

1.4 Management Structure and Integrated Program Team

This section presents the program organizational structure and roles and responsibilities of the program team.

Integrated Program Team

The Integrated Program Team for the Muon Campus will include Federal and Contractor professionals representing Architect Engineers, budget/finance, contracting/procurement, ES&H, legal, Project Management/Controls, Q/A, security, stakeholders/end users, technical managers, and others as applicable . The team size and membership will change as a program progresses. The objective of the MC IPgT is to provide professional management and subject matter expertise to ensure the safe, timely, and cost-effective completion of the program and various subprojects.

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Muon Campus Program

Organization

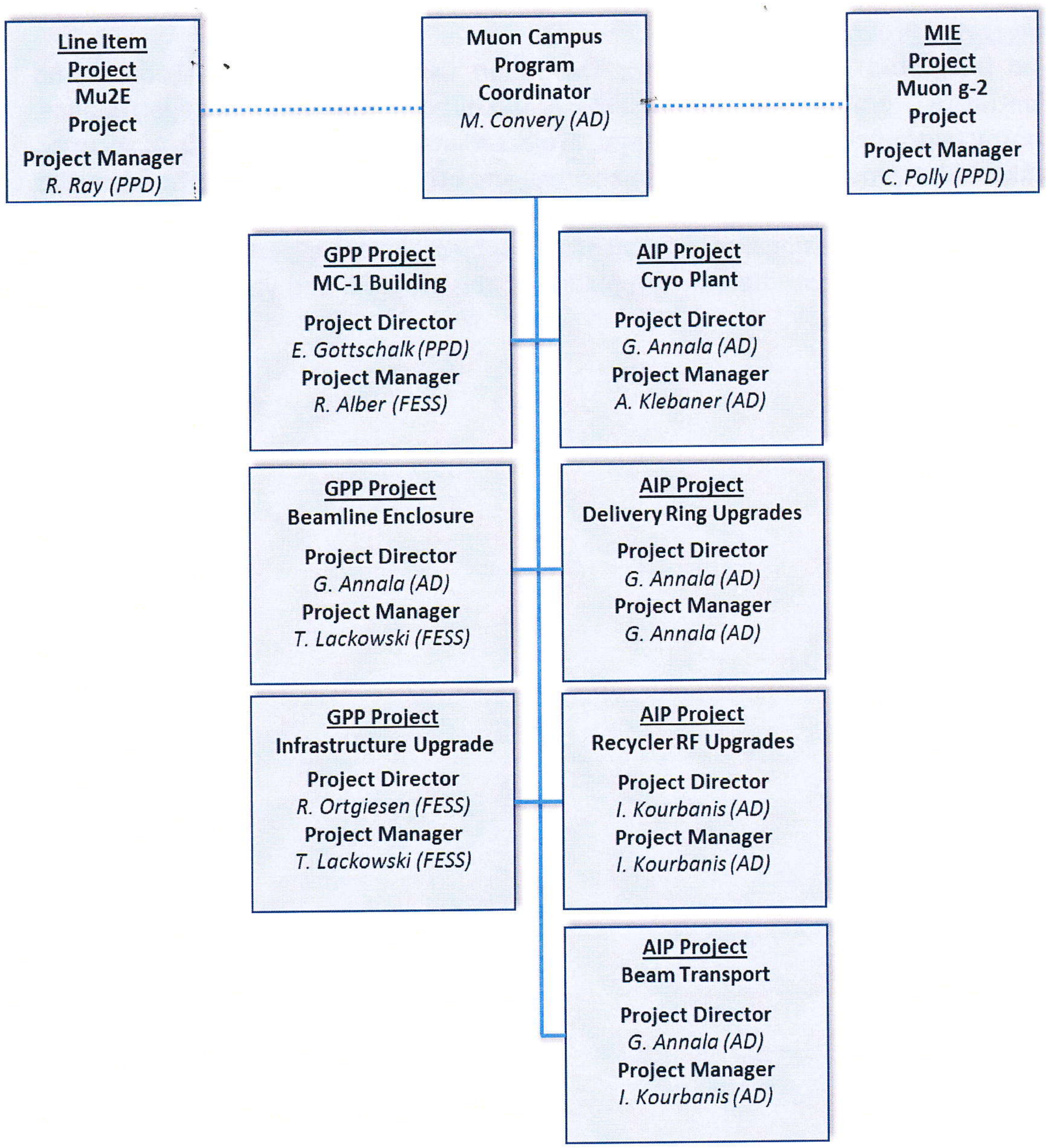

Figure 1: MC Organization Chart

DOE Federal Project Director

The FPD is part of the DOE-FSO, which reports to SC, administers the contract with Fermilab and provides day-to-day oversight of Fermilab. Overseeing the execution of the Project's is the responsibility of the FPD. The FPD is supported by matrix staff from within FSO and the SC Integrated Support Center in areas such as procurement, finance, safety, environmental compliance, and fire protection. The FPD's responsibilities and authorities include the following:

- Leads the IPgT and development of the IPgT Charter.
- Serves as the single point of contact between federal and contractor staff.
- Plans, implements, and completes the project using a systems engineering approach.
- Tailors DOE project management requirements to the project.
- Defines project objectives and technical scope, cost, and schedule.
- Ensures timely completion and quality of required project documentation.
- Assesses contractor project performance versus contract requirements.
- Proactively identifies and resolves critical issues within federal control.
- Integrates and manages the timely delivery of government reviews, approvals, property, services and information.
- Ensures the design, construction, environmental, safety, health and quality efforts performed are in accordance with the contract, public law, regulations, and Executive Orders.
- Oversees the management and mitigation of project risks.

DOE Contracting Officer

The DOE Contracting Officer provides procurement support to the FPD. The Contracting Officer coordinates the review of all subcontracts with a value greater than Fermilab's delegated authority of $5,000,000 and approves contracts with a value greater than $5,000,000 and less than $15,000,000.

Fermi Research Alliance, LLC – M&O Contractor (FRA)

Fermilab's Facilities Engineering Services Section (FESS) will lead the GPP Projects and provide the project management and facility expertise needed to successfully complete them. The GPP project's leadership is composed of individuals having several years of experience managing or supporting similar projects. The FPD will be supported by a project team that includes a Project Director, Project Manager, and other Fermilab support as shown on the project organization chart and as required by the project. Senior Fermilab management support includes involvement by the Deputy Laboratory

Director and the direct involvement of a Chief Operating Officer, who works directly with the project team to facilitate matters and assist the team with best practices.

Fermilab's Accelerator Division (AD) will lead the AIP Projects and provide the project management and facility expertise needed to successfully complete them. The AIP project's leadership is composed of individuals having several years of experience managing or supporting similar projects. The FPD will be supported by a project team that includes a Project Director, Project Manager, and other Fermilab support as shown on the project organization chart and as required by the project.

MC Program Coordinator

The MC Program Coordinator oversees the performance of the individual projects to ensure all the necessary technical and administrative planning; organizing; coordinating; and tracking (e.g., cost, schedule, deliverables), performance management, risk management, component procurement management, resource management, data management, and subcontract management required to perform all the activities successfully. The program coordinator shall keep directorate informed of any potential problems and make recommendations for solutions.

GPP and AIP Project Director

The GPP and AIP Projects will be executed by a Fermilab project team that is headed by the Project Director. The Fermilab Project Director is a key stakeholder that has accepted the scope of work as described within this project's Conceptual Design Report as being appropriate and complete. The Fermilab Project Director will initiate all scope changes and shall secure any additional funding authority as defined by the Fermilab Project Manager.

Project Manager

The GPP and AIP project manager is responsible for project implementation and evaluating and mitigating project risks. Specific responsibilities of the project manager include:

- Manages day-to-day execution of the project.
- Establishes technical and administrative controls to ensure the project is executed within approved cost, schedule, and technical scope.
- Implements an Earned Value Management System (EVMS) to track performance against the approved project baseline.
- Ensures that project activities are conducted in a safe and environmentally sound manner.
- Ensures ES&H responsibilities and requirements are integrated into the project.

- Participates in management meetings and communicates the project status and issues.
- Identifies and manages project risks.
- Prepares and provides recommendations for baseline change control proposals.
- Ensure project deliverables as defined in the contract are on time and within budget.
- Based on the size and complexity of the project, the Fermilab Project Manager, may serve as Construction Manager.

Architect-Engineer

An Architect-Engineer with an expertise in utility modeling will be selected to carry out the Preliminary and Final designs for this project. The A/E will coordinate with the CM during the design phase and provide support during the construction phase. The A/E will prepare all drawings and specifications for the construction of this facility. The A/E will also provide a portion of the construction support related activities related to design intent.

General Contractor

Fermi Research Alliance, LLC will issue construction contracts, including the management, ES&H oversight and the administration of all construction subcontracts for the Utilities Upgrade Project. This work will be inclusive of all material, equipment, labor, etc., necessary to perform the work in accordance with the contractual requirements in order to meet the defined schedule. As part of this phase, the GC is responsible for all construction related to this project.

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2.1 Scope Baseline

This section defines what project scope will be completed at Program Completion. The work outlined in the individual project plans forms the basis for the preliminary baseline scope. Requirements documents for the projects signed by Mu2e and g-2 representatives ensure that the scope is sufficient to meet the needs of the experiments. Changes in requirements will be reflected in new versions of the document, signed again by all parties. Project Completion will be accomplished when the design, construction, and start-up for the projects are complete.

2.2 Schedule Baseline

Each AIP and GPP maintains a schedule which is used to plan and track progress over the life of the project. The preliminary baseline schedule in development uses critical path methodology applied to project work activities representative of the various projects and is resource loaded. A list of project milestones committed to the DOE Project Director by the project managers is included in each project plan.

Interface milestones are the basis for communicating schedule impacts between the AIPs, GPPs, g-2, and Mu2e. This is shown in Table 1. The integration of the relevant interface milestones into the g-2 and Mu2e schedules effectively represents the overall schedule of the Muon Campus Program.

Changes to the expected achievement date of an interface milestone will be presented to the affected project manager(s) and lab management at the Muon Campus PMG. Signed acknowledgement of the new forecast dates will be recorded in the Beams Document Database.

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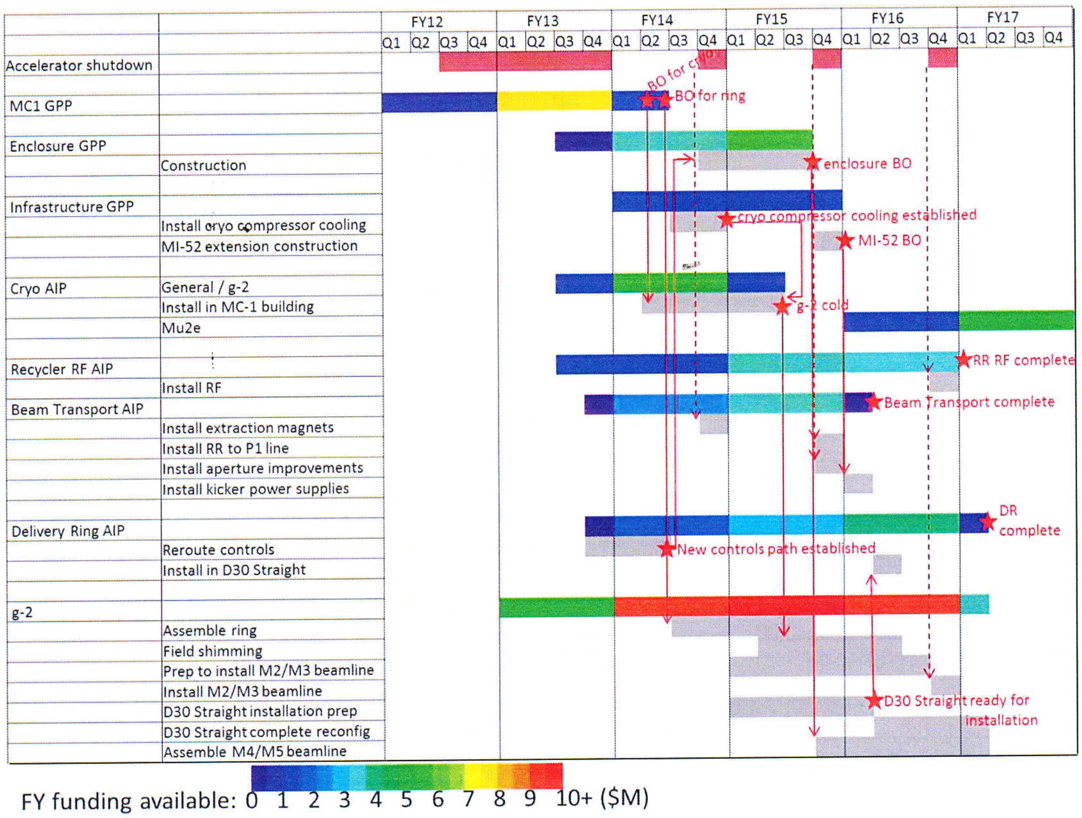
Table 1: Interface Milestones

Milestone Name	Responsibility	Impacts
MC-1 Bldg Beneficial Occupancy for Cryo	MC-1 Building GPP	Cryogenics
MC-1 Bldg Beneficial Occupancy for g-2 Ring	MC-1 Building GPP	g-2
Beamline Enclosure Beneficial Occupancy	Beamline Enclosure GPP	g-2
Cryo Compressor Cooling Established	MC Infrastructure GPP	Cryogenics
MI-52 Bldg Extension Beneficial Occupancy	MC Infrastructure GPP	Beam Transport
g-2 Cold	Cryo AIP	g-2
Mu2e Cold	Cryo AIP	Mu2e
Recycler RF Complete	Recycler RF AIP	g-2, Mu2e
Beam Transport Complete	Beam Transport AIP	g-2, Mu2e
End of Circulating Beam Studies	Delivery Ring AIP	g-2, Mu2e
Delivery Ring Complete	Delivery Ring AIP	g-2, Mu2e
MC-1 Cryo Room Controls Available	g-2	Cryogenics
D30 Straight Section Ready for Installation	g-2	Delivery Ring



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2.3 Funding Profile

This acquisition will be accommodated within the planned out year budgets of the GPP and AIP programs, subject to annual congressional appropriations.

The Total Project Cost of the program GPP's and AIP's is $55.0M. Design activities for this project will be constrained using a 'design to cost' approach. Acquisition for design activities will incorporate requirements to ensure construction cost estimates reflect the latest market conditions.

The funding profile, segregated by the type of funding is contained in Table 2 below:

Table 2: Funding Profile ($K)

Fiscal Year beginning w/CD-0	2012	2013	2014	2015	2016	2017	Total
MC-1 Building GPP	0.5	7.5	1.0				9.0
Beamline Enclosure GPP		0.4	3.7	5.6			9.7
MC Infrastructure GPP			0.5	0.5		1.1	2.1
Cryo AIP		1.1	5.1	1.3	0.8	1.4	9.7
Recycler RF AIP		0.6	1.0	3.9	3.2		8.7
Beam Transport AIP		0.2	2.5	3.7	0.3		6.6
Delivery Ring AIP		0.2	1.7	2.6	4.2	0.5	9.2
Total Project Cost	0.5	10.0	15.5	17.6	8.5	3.0	55.0

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3.1 Risk Management

An essential part of the project planning will be to ensure the risks associated with the program have been identified, analyzed, and determined to be either avoidable or manageable. Risk identification and analyses will be continued throughout the planning process, including the acquisition strategy and this document. Each of the identified risks will be monitored at each review point to ensure they have been satisfactorily addressed, eliminated, or managed.

Table 3 – Risk Summary

No.	Potential Risk	Risk Level Category
1	Funding delay due to continuing resolution	Moderate
2	Project start delay due to continuing resolution in FY11	Moderate
3	Reduced Funding	Low
4	Ongoing Operational Constraints	Low
5	Submittal of Contractor Substantial Claim	Low
6	Unavailability of subcontractors	Moderate
7	Construction Market - Bids come in too high	Moderate
8	Late Equipment/Material Deliveries by GC	Moderate
9	Existing infrastructure not adequate to support program	Moderate
10	Estimates are higher than budget	Low
11	Changes or losses key personnel	Low
12	Additional Support Costs Due to Delays	Low
13	Design Changes	Low
14	A/E design team changes or loses key personnel	Low
15	Final design delayed	Low
16	Errors & Omissions in Design by A/E	Low
17	Delay in Procurement Approval Process	Moderate
18	Defaults on contract	Low
19	Unforeseen/Undocumented subsurface conditions	Low
20	Disruptions to a Fermilab facility	Low
21	Inadequate Attention to Safety	Low
22	System Performance Does Not Meet Criteria	Low
23	Quality Deficiencies	Low

Risks continue to be monitored and managed throughout the project:

- Continue to monitor and coordinate potential security risks.
- Coordinate with operations and maintenance to minimize the effect of outages.
- Evaluate lessons learned and stress the importance of safe work practices.
- Monitor contractor performance to ensure safe work practices are followed.
- Inspect all work and material being installed for compliance.
- Ensures all adequate resources are available to implement those mitigation strategies that have been identified as Moderate and support alternative work locations in the event of a security event.
- Quantify any cost impact of the residual risks and include them in the project cost estimate. Once a baseline is approved, monitor and trend all deviations.

3.2 Project Reviews

Engineering design review is part of the Fermilab Engineering Manual and will be accomplished at several phases of design. It is a constant and ongoing process to ensure that all aspects of projects are engineered and designed to appropriate standards, they satisfy ES&H requirements, and are cost effective and meet the technical requirements.

Engineering and design is initiated by project managers and executed by engineers and designers working closely with members of the program team. The process begins with the development of requirements documents that serve as input to the engineering and design process. Project managers routinely hold internal design reviews and the engineering and design process is routinely monitored by the Project Engineers and presented to Program Management. A second engineer reviews all significant engineering designs. The Project Manager, who organizes occasional internal reviews, monitors particularly challenging engineering and design tasks closely. In some critical cases, the Project Manager will organize a task force to meet regularly until difficult engineering and design issues are better understood and under control. Technical issues that pose moderate or severe risk to the Project are documented as part of the risk assessment. Mitigation strategies, including potential work-a-rounds and fallback plans are developed. Moderate and severe risks are documented and monitored by the project manager until the risk is mitigated.

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Upon completion of the engineering and design process, drawings and documents are under configuration management control as described in the program's Configuration Management Plan. Changes to these documents are subsequently managed in accordance with the program's change control procedures.

3.3 Engineering and Technology Readiness

All equipment and work on the project involves technology based on industry standards and conventional construction practices. This project is not expected to involve highly complex or unique technologies or methods.

3.4 Environment, Safety, and Health

No environmental issues have been identified to date that would significantly impact this acquisition. All requirements of the National Environmental Policy Act and its implementing regulations will be addressed during this acquisition. A NEPA determination was completed and a Categorical Exclusion was issued. No action will be taken that could have adverse environmental effects.

All project work will be executed in accordance with applicable Public Laws, Executive Orders, OMB Circulars, Federal Property Management Regulations, and DOE Orders. All systems will be designed to applicable ASHRAE standards, and the planning, acquisition, siting, designing, construction, operating and maintenance decisions for this project will be based on considerations of LEED sustainable and DOE guiding principles as appropriate.

This work will be accomplished at the FNAL site to fulfill its strategy and mission need. While the physical work will likely cross organizational landlord boundaries and areas of radiological and environmental concern, the laboratory has well established and institutionalized controls to deal with these issues.

This project will disturb one or more acres total land area, an NPDES permit will be required. As part of the permit approval, a Storm Water Pollution Prevention Plan (SWPPP) document will need to be created and submitted to the Illinois Environmental Protection Agency (IEPA).

As part of the SWPPP, Best Management Practices will need to be incorporated into the construction documents. These items may consist of silt fences, rip rap barriers, inlet protection, and erosion control blankets, to name a few.

3.5 Safeguards and Security

The project will not change the safeguards and security requirements at Fermilab. The site is categorized as a Class PP Facility with nuclear material graded category IV attractiveness level E facility. No sensitive or classified research is conducted by Fermilab. Currently the entry gates provide perimeter access and basic visitor services and traffic management.

3.6 Configuration Management/Document Control

During project execution, documents defining the configuration of the project baseline will be maintained in document database. All baseline related documents are assigned a document number and revisions are recorded. The following project documents are the type of documents that will be under configuration control:

- A/E Scopes of Work
- Conceptual Design Reports
- Preliminary Design Report Documents
- Design Drawings and Specifications
- As Constructed Drawings
- Program Requirements Document
- Project Baseline (through BCP process)
- Hazard Analysis Documents

Non-controlled project correspondence and other records will be maintained by the project team on an internal project web site. Controlled documents will be placed and managed in the project document database, which specifies the requirements for documenting records for the design and construction of the utilities.

3.7 Systems Engineering

Systems engineering principles will be employed by the project team, subcontractors, and stakeholders in the development of the project from conceptual design through construction and completion. Over the course of the project, systems engineering will be utilized to:

- Assess and analyze alternatives incorporating user requirements, risks, costs, and constraints to arrive at a recommended alternative;
- During Preliminary Design, integrating technical requirements, risk, acquisition needs, and value management to arrive at a cost-effective, preferred solution to meet the mission need; and
- In the Execution Phase (Final Design and Construction), balance requirements, cost, schedule, safety basis, and other factors to optimize a design that matches the approved integrated baseline, and that satisfies the mission need.

3.8 Quality Assurance and Testing and Evaluation

QA principles, in alignment with Fermilab's business practices are integrated into all aspects of the design and execution of the program. The QA aspects integrated into this Plan expand on the information contained in each Laboratory's QA program by specifically addressing the 10 criteria of DOE Order 414.1A for this project. Compliance with these criteria ensures that QA will be achieved throughout the life of this project and that "lessons learned" will be documented for future projects. Implementing the quality requirements contributes to improved safety, management, and the reliability of products and services.

The scope of QA includes items, processes, and services required for:

- Planning
- Design, including consideration for long-term O&M costs
- Construction
- Process equipment procurement, specification, installation, acceptance, testing, and start-up
- ES&H associated with all activities

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- Security
- Communications and computer systems

All critical systems are subject to QA review. Typical QA processes are followed regarding design checks and approvals of the design criteria, performance specifications, preliminary and final design documents, and change orders. These are intended to ensure that at the end of the project, the configuration is the actual physical and functional configuration of the end product as reflected in as-built documents.

3.9 Transition to Operations

Upon completion of construction, Fermilab shall evaluate the facility, equipment, and systems via the beneficial occupancy process outlined in Fermilab FESS Engineering Procedures. Beneficial occupancy may occur prior to the completion of all of the commissioning and punch list items provided all life safety systems are tested and operational.

3.10 Project Closeout

A project closeout plan detailing the activities to be performed and the schedule of completion will be developed. The plan will detail contract closeout processes, the creation and distribution of a final project report, financial closeout processes, data archiving processes, lessons learned data gathering, and transfer of obligations to the new landlord organization. The plan will be developed during the latter stages of the project construction period and be implemented after beneficial occupancy for the utility system is attained.

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