Run IIb DØ Detector Project
Project Management Plan

Fermilab

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1 INTRODUCTION

This document describes the Project Management Plan that the participants will follow to meet the physics, technical, cost, and schedule objectives of the Run IIb DØ Detector Project.

1.1 Historical Background

The DØ detector was built during the period 1985-1992; commissioned in early 1992, and operated at the Fermilab Tevatron Collider (the Collider) until early 1996 (Run I). Data from this run resulted in the discovery of the top quark; precision measurements of the electroweak gauge boson parameters; extension of the understanding of the strong force through parton jets, electroweak bosons, and bottom quarks; and increased reach in the search for new particles.

Over the past nine years, the DØ Collaboration has successfully designed and constructed significant upgrades to the detector subsystems that will provide a productive, pre-eminent physics program in concert with improvements to the Tevatron Collider. These improvements are expected to result in operations at an instantaneous luminosity of up to $5x10^{32}$ cm^{-2} sec^{-1} and bunch spacings of 132 nsec. In March 2001, the Collaboration embarked on the first phase of these operations with the upgraded detector in which integrated luminosities of up to 2 fb^{-1} are expected to be achieved, and the DØ upgrade received CD-4 approval. This is refered to as Run IIa.

1.2 The Run IIb DØ Detector Project

To maximize the discovery potential of the detector at still higher integrated luminosities (up to ~15 fb^{-1}) over the next several years, additional DØ detector improvements are necessary. Beginning in CY 2000, an effort has been underway at DØ to specify those improvements. Collectively they are referred to as the Run IIb DØ Detector Project (the Project) and are the subject of this Project Management Plan. The principal elements of the Project are: (a) a replacement of the silicon tracker; (b) upgrades of the calorimeter, track trigger and L2 trigger; (c) additional components of the online system.

1.3 Overview of this Document

This document describes the Run IIb DØ Detector Project, its objectives, and how the project will be organized, managed, and reviewed in order to achieve those objectives. It supplements the "DOE Project Execution Plan for the RunIIb CDF and DØ Detector Projects" by providing additional details specific to the management of the DØ project. The following sections describe what the Project objectives are, along with a more detailed description of the actual Project itself, followed by the work plan that will allow us to realize the Project (including the WBS structure and ES&H plans), as well as the resources needed to construct the Project. The project management section addresses the organization, project management tools, change control thresholds, risk management techniques and the acquisition plan that will be implemented to assure an on-time and on-budget completion of the Project. In the final section we will present the reporting tools that will be used to track the progress of the Project.

2 JUSTIFICATION OF MISSION

The High Energy Physics program of the Department of Energy (DOE) Office of Science conducts basic research at Fermi National Accelerator Laboratory (Fermilab) utilizing the Tevatron Collider. The DØ detector is one of two detectors that observe the proton-antiproton collisions produced by the Tevatron Collider. The Tevatron Collider Run II program has been recognized by the DOE as one of the highest priority activities in the U.S. high-energy physics program. The DOE has established the mission need for the Run IIb DØ Detector Upgrade Project by completing and approving a Justification of Mission Need (CD-0) document.

2.1 Physics Objectives

The scientific objectives are presented in Section 3.1 of the DOE Project Execution Plan for the Run IIb CDF and D0 Detector Projects (PEP). We summarize these objectives below for reference.

The physics motivations for the upgrade have never been stronger. Indirect measurements continue to point to a light Higgs, with direct searches showing an excess for M_H ~115 GeV where the Tevatron is able to make a decisive discovery. Meanwhile precision measurements may be showing hints of new physics beyond the Standard Model. The DØ Detector, after completion of the Project, will continue to study the fundamental particles participating in the strong and unified electroweak interactions and search for new particles indicative of new physics. Particular physics focii will include the search for the Higgs particle(s) at masses up to ~180 GeV, and continuing studies of the top quark, the W and Z boson carriers of the weak force, the properties of hadrons containing the bottom quark, and the character of the strong force in new regimes. These physics objectives require that characteristic objects be detected and identified at all angles outside 15 degrees with respect to the beam, and that the energies of the objects be well determined. The primary objects of interest are electrons, muons, bottom quark particles, and quark/gluon jets, with neutrinos and other non-interacting particles inferred from the measurements.

2.2 Technical Objectives

A description of the technical objectives of the Project is presented in Secction 3.2 of the PEP. We outline some of the more salient features below.

The DØ Detector must operate successfully in the Tevatron Collider at an instantaneous luminosity of 5 x 10^{32} cm^{-2} sec^{-1} with bunch crossing times as small as 132 nsec. All detector subsystems must be able to withstand the accumulated radiation dose corresponding to an integrated luminosity of 15 fb^{-1}. The detector must be capable of selecting proton-antiproton collision events of interest, in real-time, from the ten million collisions per second in the Collider. Detector systems must be sufficiently reliable to assure overall efficiencies of operation of approximately 90%.

To meet the physics and technical objectives and maximize our sensitivity to new physics in the Run IIb era, the following upgrades are necessary:

- The current silicon tracker must be replaced with a device that is capable of handling the expected 15 fb^{-1} integrated Run IIb luminosity.
- Trigger rejection must be improved to maintain the present trigger rates in the face of higher instantaneous luminosity and shorter bunch spacing, and to ensure efficient triggering for key discovery channels such as $pp \rightarrow ZH \rightarrow bb\nu\nu$.
- The data acquisition (DAQ) and online systems must be upgraded to address the need for higher bandwidth data logging and filtering capability, and to address the aging and obsolescence of existing computer hardware. This system contains a portion supported through equipment money, and other portions that will be funded through the operating budget of the Laboratory. The project plan contains descriptions of both.
- In order to maximize the data-taking cycle of Run IIb, the above systems must be installed and commissioned in an efficient and timely manner. An integrated plan for these activities, under a separate WBS heading, has been developed.

The formal portion of the Project consists of those subsystems being considered for baselining by the DOE: silicon tracker, trigger, and the equipment portion of the DAQ/online upgrade. The remaining portions of the Project – the operating portion of the DAQ/online upgrade, and the installation subproject - are supported from a different source (Laboratory operating funds), but are being managed and overseen as part of the Run IIb effort.

Subsystem requirements follow from these general objectives:

- The tracking system must record the trajectories of charged particles from the collision with greater than 95% efficiency in the presence of the magnetic field. Spatial accuracy must be sufficient to detect the separation of the decays of long-lived particles from the primary interaction vertex. The tracking detectors must provide signals of high momentum electrons and muons for use in event selection.
- The calorimeter system, based on the existing uranium-liquid argon detectors, must provide the energies of charged and neutral particles with minimum noise contributions arising from the high particle fluxes, and in the presence of the ambient magnetic fields.
- Event selectivity and rejection for triggering on calorimetric energy deposition and tracking information must be maintained in the high rate environment for Run IIb. The trigger must be able to operate with adequate efficiency within the 5 kHz, 1.8 kHz, and 50 Hz bandwidth budget at the output of the Level 1, Level 2, and Level 3 trigger levels, respectively.
- The muon system must be capable of selecting events containing high momentum muons, and of measurement of their trajectories for angles above 15 degrees with respect to the beams. The detectors must be adequately shielded to minimize the extraneous noise from particles associated with radiation from the beam elements and beam-beam collisions.
- The event selection and data acquisition systems must be capable of selecting events of physics interest with no more than 15% dead time for the experiment. The recording rate of interesting events to permanent media and subsequent analysis should be approximately 50 per second.
- The experiment control systems and data logging systems must be capable of adequate real-time monitoring of the detector systems and the data quality to permit the overall efficiency goals to be met.

Documents relevant to the definition of the scope of the DØ Run IIb Upgrade are:

- "The DØ Run IIb Upgrade", April 12, 2001 (Fermilab PAC Presentation) (http://d0server1.fnal.gov/projects/run2b/Meetings/PAC/April01/April01_PAC_Presentation.pdf)
- "DØ Run IIb Project", March 19-21, 2002 (Fermilab DOE Review) (http://d0server1.fnal.gov/projects/run2b/Meetings/PAC/April02/Kotcher_DoE_Review.pdf)

More detailed design reports have been prepared for the silicon and trigger subsystems.

- "DØ Run IIb Silicon Detector Upgrade Technical Design Report", March 29, 2002, v 4.04 (http://d0server1.fnal.gov/projects/run2b/Silicon/TDR/D0_Run2b_Silicon_TDR_29Mar02_v4.04.doc)
- "DØ Run IIb Trigger Conceptual Design Report", April 8, 2002, (http://d0server1.fnal.gov/projects/run2b/ Trigger/TDR/ D0_Run2b_Trigger_TDR_V43.doc)

2.3 Cost Objectives

The estimated total project cost is summarized Table 8.2 of the PEP. In addition to support from the DOE, the financial plan for funding the Project includes contributions from D0 collaborators both in the United States and abroad, and from the National Science Foundation.

2.4 Schedule Objectives

The primary schedule objectives for the project are summarized in Table 8.3 of the PEP. The critical milestone has the silicon detector, which paces the project, ready for installation in the bore of the D0 Detector in the collision hall at the end of calendar year 2006. The trigger and DAQ projects are expected to be ready for installation in advance of the silicon, and so do are not expected to drive this end date.

3 PROJECT DESCRIPTION

The detailed Project description is provided in the Technical Design Reports. In the following sections we describe, in brief, the main elements of the upgrade and provide a brief description of the work that needs to be done to build the upgraded detector follows. We note that the calorimeter, muon, and fiber tracker detector systems will be used in Run IIb without modification.

3.1 Silicon Tracker

The current DØ silicon tracker was built to withstand the two to four fb^{-1} of integrated luminosity originally projected for Run 2. The higher integrated luminosity expected in Run IIb will render the inner layers of the present tracker inoperable due to radiation damage. Of particular importance to being able to collect the data needed for the Higgs discovery in a timely manner is completion of the replacement detector in approximately three years with minimal Tevatron down time. The new tracker will be assembled at Fermilab from commercially produced silicon microstrip sensors, hybrids, and readout electronics. The current plans call for a tracker having six axial and four stereo layers, with a simple modular design and a minimum number of different part types. The proposed baseline detector has 1656 silicon sensors, 7512 SVX4 readout chips and a total of 962K channels. Its length has been chosen to permit its insertion into the bore of the fiber tracker without the need to move the DØ detector from the Collision Hall, a feature that is desired because of the relatively short (~6 month) shutdown that is currently planned between Runs IIa and IIb.

3.2 Trigger System

The Run IIa trigger will be modified to deal with the higher instantaneous luminosities (up to 5×10^{32} $cm^{-2}sec^{-1}$) and possibly shorter bunch spacings (132 nsec) expected in Run IIb. Reductions in the Level 1 trigger rate of factors of three to four will be required. The majority of this reduction will be achieved through changes in the Level 1 calorimeter trigger that will involve replacement of the trigger logic hardware and modifications to trigger algorithms. Changes to the Level 1 Central Track Trigger will also be necessary. These involve the utilization of fiber singlets, as opposed to the currently used doublets, to enhance the rejection in the Level 1 track trigger. This upgrade will exploit increased processing power on FPGAs housed on new daughter cards that will be installed in the existing system. A match of candidate tracks with calorimeter information of increased granularity at Level 1 (Cal/Track Match) will also be employed.

The Level 2β and the Level 3 trigger systems will undergo upgrades to the existing processors to take advantage of the processing speed and power increases that will inevitably occur. The upgrade to the Level 2 silicon track trigger (STT) will be a modest 4- to 5-layer extension of the Run IIa system, designed to adequately map to the extended silicon detector being used for Run IIb. As elsewhere, commercial resources will be used wherever possible in the fabrication of the electronics.

3.3 Online Computing

The online computing system is comprised of all computer equipment and software required to operate, monitor and control the experiment. It includes subsystems to control the trigger system and frameworks, manage event flow to tape and monitoring queues, control front-end electronics, handle alarms and monitoring information from all components of the experiment, and monitor the quality of the data taken. The hardware will be assembled from commercial equipment, and, where possible, procurements will be deferred to the latter stages of the project to obtain optimal capability for a given price. System software and some application software packages will be purchased from commercial suppliers. The specialized software to run this particular online system and to perform the special and unique tasks required will be developed by members of the Collaboration. Upgrades to the online system include new ORACLE database systems, upgrades to the fileserver, and increased processing power in the Level 3 filtering farm. This subsystem consists of both equipment and operating portions (see Section 2.2 and Section 5).

3.3’ <u>Installation</u>

A separate WBS Level 2 element has been called out for Run IIb installation and commissioning to enable the development of an organized, integrated project-wide plan that will be used to take the upgraded experiment from installation through to data-taking readiness. The silicon and trigger subsystems are overseen at WBS Level 3, with the silicon effort partitioned into mechanical and electronics sub-elements. All aspects of mechanical and electrical infrastructure and installation, and associated in-situ technical commissioning, are included here: silicon detector installation and alignment; installation, hookup, and commissioning of the silicon readout; installation of new trigger boards, cables, rack preparation, and other hardware; and commissioning of the trigger systems. While being fully overseen as part of the Project, this subproject is being supported by Laboratory operating, rather than equipment, funds (see Section 2.2 and Section 5).

3.4 R&D Program

The research and development effort associated with the Project officially started in 2000 with the formation of a Run IIb DØ working group to study possible upgrade options for the silicon detector. A series of trigger workshops also was held to better define the trigger improvements needed for Run IIb. The full-replacement option for the silicon detector was selected, along with the decision to use the SVX4 readout chip technology. The SVX4 chip development is a joint R&D effort with CDF.

R&D work continues on the mechanical and electronic portions of the silicon detector, with prototypes of various components being developed at Fermilab, university collaborators, and in conjunction with outside vendors. Research and development and prototyping also continues on the trigger systems, with plans for fabrication of prototype Level 1 calorimeter trigger ADF boards being scheduled for early calendar year 2003. In-situ testing of these components is expected to begin at D0 shortly thereafter. In addition, development of the Level 1 Central Track Trigger and online systems continues, providing concrete input to the corresponding project plans.

4 PROJECT MANAGEMENT, ORGANIZATION AND RESPONSIBILITIES

4.1 Overview

The DØ Run IIb Upgrade Project is primarily funded by the DOE and managed through Fermilab. It is carried out in collaboration with universities and laboratories in the US and other countries. Its goal is to upgrade and improve the existing DØ detector to fully exploit the properties of the Tevatron available in the Main Injector era. The project is to be managed to a predetermined scope, cost and schedule. The responsibilities for managing the project are represented in the following organization chart and are described in the following sections of this chapter.

4.2 Department of Energy

The Department has established the need for the DØ Run IIb Upgrade Project by considering and responding to advice from its advisory panel, HEPAP, and to Fermilab requests in field task proposals, and by participating in peer review processes for the Fermilab program including the annual DOE laboratory-wide review and the Fermilab Physics Advisory Committee meetings. The Department of Energy provides the majority of funding for the DØ Run IIb Upgrade Project. These funds are provided through the Fermilab annual financial plan by contract modification. The Division of High Energy Physics provides annual program guidance to the laboratory as well as annual guidance on the funding profile for the project. The Department exercises oversight of the by:

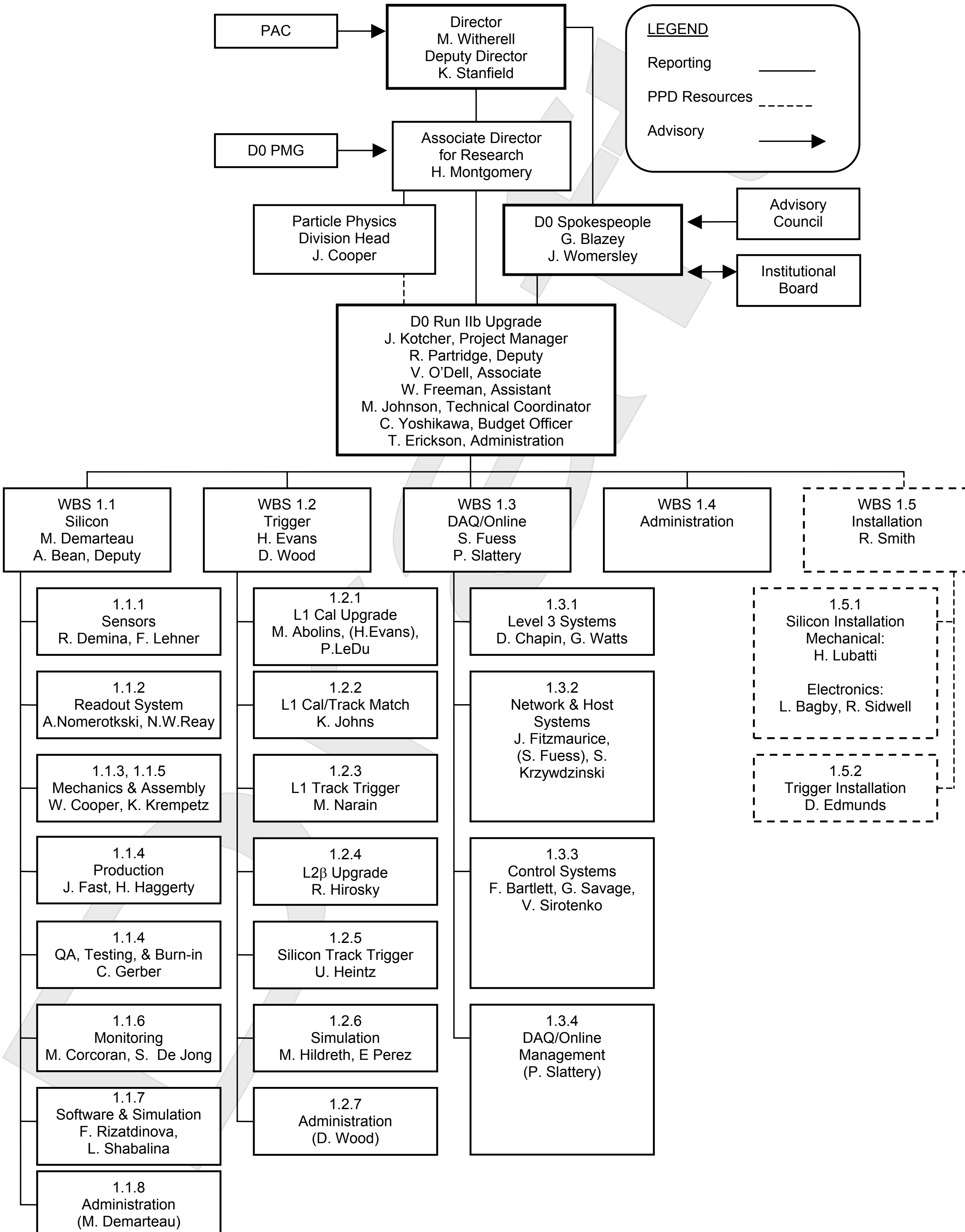
- conducting periodic reviews of the project;
- participating in regularly scheduled Project Management Group (PMG) meetings;
- overseeing operations and fabrication activities;
- monitoring project progress via monthly reports; and
- monitoring milestones/performance measures.

The day-to-day management responsibility, authority and accountability is assigned to the DOE Run II Project manager. The management structure of the Project for the DOE is described in detail in the DOE Project Execution Plan.

4.3 Fermilab Director

The Fermilab Director is responsible to the Universities Research Association and the Department of Energy for the successful completion of the DØ Run IIb Upgrade Project and only he is authorized to commit funds appropriated for Laboratory use. The Director approves the scope of the upgrade project with advice from the Fermilab Physics Advisory Committee (PAC) in response to proposals from the DØ Collaboration. Decisions regarding the scope of the upgrade are made in a two-stage process. Stage I approval is given to endorse the scientific merit of the proposal when sufficient information is known regarding technical designs so that costs and schedules can be estimated. Resources can then be allocated so that a Project Management Plan can be developed, detailed technical designs can be prepared, and cost estimates and resource-loaded schedules can be made. In addition, a financial plan identifying the necessary funding resources must be prepared. Upon the successful completion of these plans Stage II approval is granted by the Director upon advice of the PAC. Approval for the project may proceed in parts, subsystem by subsystem. Construction of a subsystem normally begins after Stage II approval has been granted for that subsystem but may proceed earlier with the Director's approval.

The Director approves or concurs with the contents of the Technical Design Reports (TDR), the Project Management Plan, the cost estimate, the schedule, the financial plan for the project, and changes of scope to the project.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1.1.4
QA, Testing, & Burn-in
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1.1.6
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L1 Cal Upgrade
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1.2.2
L1 Cal/Track Match
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1.2.3
L1 Track Trigger
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1.2.4
L2β Upgrade
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1.2.5
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1.2.7
Administration
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1.3.3
Control Systems
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1.3.4
DAQ/Online
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Silicon Installation
Mechanical:
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Electronics:
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1.5.2
Trigger Installation
D. Edmunds

4.4 Fermilab Associate Director For Research

The Director has delegated certain responsibilities and authority to the Associate Director for Research. The Associate Director for Research is responsible for management oversight of the Project. Oversight of the Project will be implemented in part through reviews including the Project Management Group (below) and/or Director's Reviews. Along with routine interactions with project management, these reviews will identify actions and initiatives to be undertaken to achieve the goals of the project including allocation of financial and human resources. Progress will also be monitored through presentations to and discussions with the PAC.

To implement the work plan for the Project, Memoranda of Understanding are executed with collaborating institutions. The Associate Director for Research approves all Institutional Memoranda of Understanding (MoU) related to the Project. He is responsible for providing a funding profile consistent with Laboratory funding after consultation and guidance from the DOE program office. The Associate Director for Research advises the Director on his approval of the Technical Design Reports, the Project Management Plan (PMP), the cost estimate, the schedule, and the financial plan and concurs with these approvals.

4.5 Fermilab Particle Physics Division Head

The Fermilab Director and Associate Director for Research have delegated certain responsibilities and authorities to the Fermilab Particle Physics Division (PPD) Head. The PPD Head is responsible for portions of project management and oversight as the line manager for financial resources, human resources, technical resources, space resources, and ES&H issues for this project. The Project Manager reports to the Associate Director for Research directly and through the Head of the PPD.

The PPD Head and his/her deputies are members of the Project Management Group. The PPD Head advises the Associate Director for Research on approval of Memoranda of Understanding relevant to PPD resources and concurs in these approvals. The PPD Head advises the Director and Associate Director for Research on approval of the PMP and the Cost/Schedule Plan (CSP) and concurs with these approvals.

On advice from the Director, the PPD Head allocates yearly budgets to the Project. These project funds are then administered by the Project Manager within the context of PPD procedures and policies and with the aid of the PPD budget office.

The PPD is the primary source of Fermilab manpower and technical resources for the project. The PPD Head and his/her designees make long-term assignments of PPD people directly to the project in consultation with the Project Manager and in accordance with the CSP. The Project Manager then utilizes these people to achieve the project goals, reporting changes in assignments to the PPD Head. The PPD Head maintains line management responsibility for these PPD employees and the Project Manager is part of the line management chain.

The PPD also provides support to the project through PPD technical resource groups. This is done in accordance with the CSP via specific work plans or Memoranda of Understanding. The PPD Head maintains direct line management responsibility for such PPD resources.

Since the Particle Physics Division is the primary source for providing the Fermilab labor needed to achieve the project schedule goals, labor shortfalls must be reported in a timely fashion. The PPD head or designee will advise the Project Manager and Associate Director for Research and report to the DØ PMG when insufficient labor is available to meet the levels indicated in the CSP. In this event, the Project Manager will conduct a schedule impact study and submit a schedule variance as appropriate to the Associate Director for Research as required by the project controls.

4.6 DØ Spokespersons

The DØ Spokespersons provide the means of contact between the DØ Collaboration and the Laboratory. They speak for the Collaboration and represent the Collaboration in interactions with the Laboratory. The

DØ Spokespersons are responsible for all aspects of the DØ Experiment, including the operation of the current detector, the analysis of data and production of physics results, and the improvement of the detector defined by the approved scope of the DØ Run IIb Upgrade Project. The Spokespersons are elected by the Collaboration. In doing so, the Collaboration consults with the Director and he concurs in the selection.

4.7 DØ Run IIb Upgrade Project Manager

The DØ Run IIb Upgrade Project Manager is responsible for all aspects of the Project. The Project Manager is designated by the Spokespersons with the concurrence of the Laboratory Director. He is appointed by the Director to manage the project to the approved scope, cost and schedule. A non-Fermilab collaborator may be appointed as the Project Manager after receiving a Guest Scientist appointment at the Laboratory. The Project Manager is responsible for developing and coordinating support for the project from various organizations including the DØ Project, other units within the Laboratory, and institutions in the Collaboration. This support includes engineering and design, procurement and fabrication, administration, financing and scheduling.

The Project Manager has the responsibility to complete the DØ Run IIb Upgrade Project on schedule, on budget, and within the agreed upon scope by managing the resources of the Collaboration and the Laboratory. He has fiscal authority over Fermilab funds allocated to the Project and is responsible for monitoring expenditures of US and non-US funds. He tracks and reports deviations from baseline schedules and costs as specified in the Project Management Plan. The Project Manager reports to the Associate Director for Research directly and through the Head of the Particle Physics Division on all matters concerning the Project related to managing the Project to the approved scope, cost and schedule. He reports to the Associate Director for Research on all matters which have the potential to result in commitments of the Laboratory or the Universities Research Association.

The Spokespersons, representing the Collaboration, seek approval for all scope changes having a significant impact on the physics capability of the upgraded detector by making scientific proposals to the Director. The Director may seek the advice of the Physics Advisory Committee when considering these proposals. The Director approves all such scope changes, those that increase the scope as well as those that reduce it. The Project Manager reports to the Spokespersons on all technical and scientific issues of the Project. The Project Manager may identify the need for out-of-scope changes as they arise. When there is a need for a change having a significant impact on the physics capability of the detector, they report to the Spokespersons and also identify the need to the Director through the PMG. Other changes follow the change control procedures below.

The Project Manager is responsible for the Project Management Plan and for updating it as necessary with the approval of the signatories to this document.

The Project Manager is responsible for organizing presentations at reviews and status reports on the Project as needed to respond to the Director and funding agencies. He is the authority to speak for the Collaboration on technical questions raised in these processes.

The Project Manager is responsible for the completion and approval of Technical Design Reports for each subsystem.

4.8 DØ Upgrade Subproject Managers

All WBS Level 2 and Level 3 subprojects are managed by individuals appointed by the Project Manager, with the concurrence of the Spokespersons. The Subproject Managers manage and direct their subprojects and report to the Project Manager. They are directly responsible for generating and maintaining the cost-estimate, schedule, and resource requirements for their subprojects. They are responsible for meeting the goals of their subproject within the accepted baseline cost and schedule.

4.9 DØ Collaborator Responsibilities

The responsibilities of DØ Collaborators are specified in comprehensive Memoranda of Understanding. The MoU details the work that the Collaborator has agreed to do for the Project, and includes a list of the personnel involved, a budget for the current Fiscal Year, and significant milestones. These agreements are updated as appropriate, typically through Addenda to specify the budget for the next Fiscal Year. They are approved by the DØ Contact Person and appropriate responsible parties for the collaborating institution and by the Project Manager, the DØ Spokespersons, the Particle Physics Division Head, and the Associate Director For Research. The Project Manager has responsibility for coordinating all Collaboration-wide resources via these MoU's and he has the authority to negotiate with all institutions for allocation of these resources. These MoU's are components of the Work Plan for the project and, as such, are considered part of the PMP.

4.10 Advisory Functions

4.10.1 DØ Executive Committee

At the discretion of the Spokespersons, major decisions of the DØ Collaboration, especially those of an organizational, institutional, or broad scientific nature, are discussed with the DØ Executive Committee. The Committee advises the Spokespersons. Each of the collaborating institutions (including the Fermilab DØ Project) is represented. The DØ Project Manager participates in the deliberations of this body.

4.10.2 DØ Upgrade Managers Group

The DØ Upgrade Managers Group is comprised of the Project Manager, Deputy Manager, Technical Coordinator, the Subproject Managers, additional personnel from the Project Office, and others as the need arises. This group serves as a forum for discussion of technical and management issues in the project and is advisory to the Project Manager. It also provides a convenient mechanism for the dissemination of information. The WBS Level 3 Subproject Managers often participate in these meetings.

4.10.3 DØ Project Management Group (PMG)

The Associate Director for Research will chair a Project Management Group that will meet as required to monitor the progress of the project. The meetings will be attended by those who have responsibility for the Project and by those who have authority to redirect resources within the Laboratory and the Collaboration. The PMG will also serve as the Change Control Board for the project.

4.10.4 DØ Institutional Board

The DØ Institutional Board is comprised of single voting members from each institution (except for Fermilab which has two). This board is generally advisory to the Spokespersons except for the responsibility for deciding on: DØ governance issues; the admission of new collaborators; the nomination (together with individual collaboration members) of spokesperson candidates to the ballot; the selection of the chair of the institutional board; and, under exceptional circumstances, the need to call for new Spokesperson elections (which requires a 2/3 majority).

4.10.5 DØ Finance Committee

The DØ Finance Committee consists of a DØ physicist and a representative of non-U.S. funding agencies for each agency funding DØ. Since the U.S. contribution comes through Fermilab, the Fermilab Associate Director of Research will be the U.S. funding agency representative on the committee. This Committee oversees the use of financial contributions by these groups to the costs associated with the operation of the experiment and the upgrading of the detector.

5 WORK BREAKDOWN STRUCTURE

All work required for completion of the Project is organized into a heirarchical Work Breakdown Structure (WBS). The WBS constitutes a complete definition of the scope of the project and forms the basis for its planning, execution, and control. The foundations of the WBS for the technical components are a Technical Design Report for the silicon detector and a Technical Design Report for the Trigger Upgrades. The WBS is expressed through a resource-loaded schedule with appropriately linked tasks. The schedule contains both M&S and labor costs and contingencies on a task-by-task basis, as well as a series of project milestones which aid in the the estimation of the project end date. The WBS structure to level 3 is shown in the organization and reporting chart in section 4.3.

The two major systems that comprise the Run IIb Upgrade Project are represented at WBS Level 2: These are the Silicon Tracker (1.1) and the Trigger Upgrades (1.2). There are additional WBS Level 2 items for DAQ and Online (1.3), Administration (1.4) and for Installation (1.3). The task-based WBS extends downward through many additional levels to faciliate cost, schedule and resource planning. The WBS structure of the technical components through Level 3 is described below.

WBS 1. DØ Run IIb Project

This Level 1 summary element consists of all those components of the actual Run IIb upgrades of the DØ detector: the silicon, trigger, DAQ, and online upgrades, installation and commissioning, and administration. ~~and the associated online computing system necessary to process the data.~~

WBS 1.1 Silicon Tracker

One of the most powerful developments in tracking technology has been the advent of silicon microstrip detectors. This level 2 summary element covers the design, procurement, construction, and testing of a sophisticated radiation-hard silicon tracking detector to replace the Run IIa silicon detector. It will be located immediately outside the beam pipe and provides high-precision tracking and vertex determination. This element includes the silicon tracker sensors, their mechanical supports, readout electronics, associated mechanical and electrical infrastructure, and software.

WBS 1.1.1 Sensors

This summary element includes the development and procurement of commercial silicon sensors for all layers of the detector, as well as the setup of detector probing stations, sensor probing and acceptance testing, radiation testing, and vendor qualification and monitoring.

WBS 1.1.2 Readout System

This summary element includes the development, procurement, and testing of SVX4 readout chips, readout hybrids, cabling, junction cards, test cards, adaptor cards, interface boards, and power supplies, as well as improvements to selected elements of the front-end DAQ system.

WBS 1.1.3 Mechanical and Assembly

This summary element includes the development and fabrication of assembly fixtures, tooling, and support structures for sensors, readout components, and the fully assembled detector. Also included are mechanical and electrical infrastructure items such as mounting hardware, a detector cooling system, a dry-gas purge system, equipment protection interlocks, and alignment monitoring hardware.

WBS 1.1.4 Production, Quality Assurance, Testing and Burn-in

This summary element includes all tasks associated with the production of the silicon tracker. It also includes the hardware and software used in testing and quality assurance activities associated with silicon sensor, hybrid, and detector module production. Test stands/stations, storage boxes, commercial diagnostic and database software for recording test and burn-in results are included in this element.

WBS 1.1.5 Mechanical and Silicon Barrel Assembly

This summary element includes the integration, assembly, and alignment of the silicon barrels. This includes the bulkhead installation, barrel-to-barrel alignment fixturing and measurement, installation and alignment of tested staves, final installation of cooling and dry-gas elements, cable pathways and associated strain relief hardware, and items and elements associated with the packup and shipment of the silicon detector to D0 Assembly Building for installation.

WBS 1.1.6 Monitoring

This summary element includes the procurement of hardware and detectors for radiation monitors that measure dose and dose rate delivered to the silicon detector. It includes silicon diodes, hybrids, cabling, and readout electronics. It also includes procurements and system development for temperature monitoring, including temperature sensors and associated cabling and readout electronics.

WBS 1.1.7 Software and Simulation

This summary element includes procurement of CPU, and laptop computers, and associated commercial software packages for the purpose of aiding in the testing, debugging, readout, and status monitoring of the silicon detector. It also includes the physics simulation effort that provides input as the design of the silicon detector is developed.

WBS 1.1.8 Administration

This summary element includes the cost of travel, administrative personnel, and other costs associated with managing and overseeing the silicon detector subsystem.

WBS 1.2 Trigger

In order to accommodate the shorter bunch spacing and the increase in luminosity, the three level trigger system at DØ needs to be upgraded. This summary element includes improvements to the upstream hardware trigger levels – Levels 1 and 2 - of the trigger system.

WBS 1.2.1 Calorimeter Trigger Upgrade (L1 Cal)

This summary element covers the Level 1 calorimeter trigger modifications. It includes development and procurement of ADC/digital filter boards (ADF), development and procurement of trigger- and global-algorithm boards (TAB and GAB), the provision of output signals to facilitate a match between calorimeter towers and tracks, and procurement and improvements in associated readout crates, power supplies, cabling, and controls hardware.

WBS 1.2.2 Calorimeter Track-Matching (Cal/Track Match)

This summary element provides for improvements in the Run IIa track-matching trigger. It includes development and procurement of slightly modified versions of existing Level 1 muon cards, and procurement of related cabling, connectors, readout crates, processors, and power supplies.

WBS 1.2.3 Central Track Trigger (L1 Track Trigger)

This summary element provides for improvements in the existing track trigger. It includes design and development of algorithms that utilize larger FPGAs, the development and procurement of new Digital Front-End (DFE) boards that utilize these FPGAs, and procurement and programming of the new FPGAs.

WBS 1.2.4 Level 2β Upgrade
This summary element includes the procurement of additional single-board computers (Level 2 Beta processors), associated hardware, and firmware support needed for improvements to the Level 2β system.

WBS 1.2.5 Silicon Track Trigger
This summary element includes upgrades to the Run IIa silicon track trigger to adapt it to the increased number of inputs from the Run IIb silicon detector. It consists of the procurement of additional electronics boards of the Run IIa type, as well as firmware changes and additional cabling and connector hardware.

WBS 1.2.6 Simulation
This summary element includes the integration of the simulation effort needed for development of the trigger elements, including development of the necessary software to carry out these studies. Due to the individual software needs of the various trigger subprojects for testing and commissioning, these particular portions of the subprojects are included in the individual WBS elements for the trigger outlined above.

WBS 1.2.7 Administration
This summary element includes the cost of travel, administrative personnel, and other costs associated with managing and overseeing the trigger subsystems.

WBS 1.3 DAQ/Online
This summary element contains upgrades that address aging and obsolescence of DAQ and online hardware. It also contains improvements to the DAQ and online system that are required to accommodate the need for higher bandwidth data logging and enhanced filtering capability at Level 3. It includes new ORACLE database systems, upgrades to the fileserver, and increased processing power in the Level 3 filtering farm. As mentioned in Section 3.3 above, this WBS element contains portions supported through both equipment and Laboratory operating funds.

WBS 1.3.1 L3 Systems
This summary element contains upgrades that pertain to the processor farm based Level 3 system.

WBS 1.3.2 Network and Host Systems
This summary element contains upgrades that pertain to the network infrastructure and the online host computer system.

WBS 1.3.3 Control Ssystems
This summary element contains upgrades that pertain to the EPICS based control system infrastructure.
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WBS 1.3.4 DAQ/Online Management
This summary element includes the cost of travel, administrative personnel, and other costs associated with managing and overseeing the DAQ and online subsystem.

WBS 1.4 Administration
This summary element includes all tasks related to project management, including salaries of relevant project mangement personnel or support staff, travel, computers or other hardware specific to project office activities, and office supplies needed for reviews and other project functions.

WBS 1.5 Installation

This summary element includes all equipment used to install and commission the silicon, trigger, and DAQ/online elements of the Project. Included are installation hardware, transportation and associated fixturing, all cooling and gas infrastructure, and cabling, hookup and checkout of the relevant systems. As mentioned in Section 3.2 above, the financial support for this system will come from Laboratory operating funds.

WBS 1.5.1 Silicon Installation

This summary element includes the uncabling and removal of the existing silicon detector, as well as the equipment used to transport and install the completed silicon detector at DØ. It includes transportation, installation, and alignment fixtures, as well as hardware associated with the cooling and dry gas systems that is used to connect the detector as part of its final hookup. Other infrastructure, including chillers and associated piping, are included. Installation, hookup, and commissioning of the readout electronics, including cables, high voltage, adapter cards and associated infrastructure, is also included.

WBS 1.5.2 Trigger Installation

This element includes the disassembly of all existing trigger elements, the preparation of the associated readout racks, and the installation, cabling, and technical commissioning of all trigger, DAQ, and online electronics boards.

6 RESOURCE PLAN

The planned funding profile for the Project can be found in Table 5.1 of the PEP. It includes all sources of funding including those from DOE, D0 collaborators, and NSF MRI funding.

The staffing plan profile for the Project is given in the following table in units of FTE's. The categories shown include all collaboration-wide physicist manpower (Physicist), and technical manpower provided by collaborating institutions (Technical-University) and Fermilab (Technical-Fermilab). Note that physicist manpower is not included in any funding profile, and not all technical manpower provided by collaborating institutions is included in the funding profile.

	Prior Years	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**	**FY 2006**	**Total**
Physicist							
Technical University							
Technical Fermilab							
DØ Total							

7 TECHNICAL, SCHEDULE, AND COST LIFE-CYCLE

7.1 Project Scope & Technical Approach

The technical baseline is described in detail in the Technical Design Reports for the Silicon Tracker and the Trigger Systems. This latter document includes our technical plan for the DAQ and online systems. We also refer the reader to Section 3.2 of the PEP for a description of the technical goals of the Project, enumerated therein in Table 3.1.

7.2 Project Schedule

A comprehensive schedule of work to design, construct, assemble, and commission the upgraded DØ detector is maintained to facilitate management of the Project. It is comprised of detailed schedules for the development of each subsystem in the project and includes the resources (cost, manpower) required for each step. Based on these details, an overview of the project has been fashioned, complete with cost and manpower needs as a function of time and a series of milestones spread throughout the project. The WBS structure is defined through this schedule.

7.2.1 Schedule Methodology

The schedule is assembled using Microsoft Project 2000. Subproject managers are responsible for the generation and maintenance of the schedules for their subsystems, in collaboration with the Run IIb Project Office.

The schedule is built of tasks of various durations and milestones that are linked to describe the flow and interdependency of the work. The manpower required to complete each task is specified. Separate allocations are made for various types of technical personnel – including mechanical and electrical engineers, designer/drafters and technicians, as well as physicists, both for Fermilab and non-Fermilab employees. Thus, profiles in time of various work groups are readily obtained to aid in the establishment of manpower requirements and the allocation of personnel as the Project evolves. By entering the average hourly SWF cost of each type of manpower, labor cost profiles are extracted for each work group as well as the total labor cost for each subproject and for the entire Project.

The M&S funds needed to complete each task are determined and assigned directly to the tasks in the schedule. Cost plans for each subproject and for the full project can then be derived. Using this information, a consistent and viable work plan can then be established by making appropriate adjustments to the schedule to yield an overall cost plan that matches the profile of funds available from the Laboratory and other sources, and a manpower plan that can be supported by the Laboratory. We note that for all M&S and labor estimates, a detailed Basis of Estimate (BoE) is provided that described the foundation of and justification for the predicted need as outlined in the schedule. We have found our experience in completing the Run IIa upgrade to be a valuable guide in estimating our needs for the Project.

The scheduling program identifies the critical path (or paths) to completion of the Project. This feature calls attention to those tasks that have no 'float' or slack that must be carefully monitored to prevent delay. Knowledge of the critical path facilitates changes to optimize the work and to hasten completion.

7.2.2 Project Schedule

The baseline schedule that is consistent with the available funding and manpower resources, has been assembled. The schedule is monitored by the Subproject Managers and the Project Manager. A comprehensive set of milestones scattered throughout the duration of each subproject are monitored by the Subproject Managers. A subset of these are monitored by the Project Manager, and further subsets are held by the Director and at various levels in the DOE. These "Director's Milestones" are shown in the table below. DOE milestones are indicated in boldface type.

No.	Director's Milestones	Date
1	Milestone A	dd-Mon-yy
2	Milestone B	dd-Mon-yy
3	SVX4 Released for Production	dd-Mon-yy
4	Milestone D	dd-Mon-yy
6	Silicon Tracker Assembly Complete	dd-Mon-yy

7.3 Manpower Requirements

Manpower profiles are extracted from the schedule for the various categories of personnel mentioned earlier. The results are displayed in the table below listing the average number of people (FTE's) in various technical job categories to support the plan. (F) denotes Fermilab manpower, (U) denotes non-Fermilab manpower.

Position	FY01	FY02	FY03	FY04	FY05	Total
Designer (F)						
Electrical Engineer (F)						
Electrical Technician (F)						
Mechanical Engineer (F)						
Mechanical Technician (F)						
Computer Professional (F)						
Sub-Total (F)						
Designer (U)						
Electrical Engineer (U)						
Electrical Technician (U)						
Mechanical Engineer (U)						
Mechanical Technician (U)						
Sub-Total (U)						

Total (F+U)

7.4 Project Cost

The cost estimate for the Project covers all Materials & Services and those Salaries, Wages and Fringe Benefits budgeted to capital funds for the Project for all WBS levels.

7.4.1 Cost Spreadsheet

The costs are estimated at the lowest available level where there is a sufficient level of detail to provide reliable cost estimates and contingency analyses. They are assigned line by line into the schedule. Contingency for labor and M&S is computed and tracked separately. The Project Manager is able to review the costs at any level of detail by examining the roll ups of tasks within a given class. The cost estimates provided by the Subproject Managers are reviewed by the Project Manager in consultation with any technical experts that are deemed necessary to evaluate the cost estimates. The costs in the schedule are given in FY02 dollars. Appropriate overhead and escalation is done external to Microsoft Project 2000, either by hand or within the COBRA accounting program that is used to compute earned value. It is foreseen that all project tracking and accounting will be done within the COBRA structure for the duration of the Project.

7.4.2 M&S Contingency Estimation

There are two estimates of contingency made for the Project. One estimate is made by the WBS level 3 Subproject Managers at the lowest available level. It is based on detailed estimates of designs where available, and on the experience of the Subproject Managers and the engineering staff directly involved with the subsystem where a conceptual design exists. Guidelines for the estimation of the contingency have been provided, but may be overridden by the Subproject Managers in exceptional cases. The general guidelines for the contingency estimation for M&S are:

- 0% on items that have been completed.
- about 10-15% on items that have been ordered, but not delivered (this accommodates change orders, delivery costs, etc.)
- about 30-50% on items that can be readily estimated based on quotes for a detailed design
- about 50-70% on items for which a detailed conceptual design exists, but which may vary due to scope changes such as channel count
- about 70-100% on items for which there does not yet exist a detailed conceptual design, but which is an item required for the Project

In addition, the Project Manager constructs a "top-down" estimate of the contingency based on past experience, DOE guidelines, and the fiscal history of similar completed projects. The Project Manager makes the ultimate determination of the M&S contingency, taking his own estimate and that constructed by the lower level managers into consideration.

7.4.3 Labor Contingency Estimation

Contingency on labor estimates is handled in an analogous manner to those for M&S. The overall guidance provided by the Project Manager to the Subproject Managers for labor contingency estimation is 50-75%. This can be overridden in exceptional cases, and should be tailored to the time evolution of the project. For example, estimates for labor contingency may be augmented during peak production periods in order to adequately cover this labor-intensive portion of the Project.

7.4.3 Cost Summary

The summary of all Equipment M&S, Project Support costs and Operating SWF, is presented in the following table in FY02 k$. The full detailed cost estimate for each subsystem is presented in Chapter 10. A summary of the Total Project Cost can be found in Table 8.2 of the PEP.

WBS	ITEM	DETECTOR			
		M&S	Contingency		Total
1	D0 RUN IIb UPGRADE DETECTOR	k$	%	k$	k$
1.1	***Silicon Tracker***				
1.1.1	Sensors				
1.1.2	Readout System				
1.1.3	Mechanical Design and Fabrication				
1.1.4	Detector Production and Testing				
1.1.5	Monitoring				
1.1.6	Installation				
1.1.7	Readout Software				
1.1	TOTAL SILICON TRACKER				
1.2	***Level 1 Trigger***				
1.2.1	Calorimeter Trigger Upgrade				
1.2.2	Calorimeter Track-matching				
1.2.3	Tracking				
1.2	TOTAL LEVEL 1 TRIGGER				
1.3	***Level 2 Trigger***				
1.3.1	Level 2 Beta Processor Upgrade				
1.3.2	Silicon Track Trigger				
1.3	TOTAL LEVEL 2 TRIGGER				
1.5	Online Improvements				
1	TOTAL D0 UPGRADE PROJECT				
2	**DETECTOR R&D**				
3	**PROJECT SUPPORT**				
3.1	***Project Management***				
3.2	***Fermilab Technical Support***				
	TOTAL PROJECT SUPPORT				
	Equipment G&A				
	Operating G&A				
	OPERATING SWF FY01-05				

8 CHANGE CONTROL THRESHOLDS

Any change to the Project that does not alter the scope of the Project as defined above does not require a new proposal to be submitted to the Laboratory. Although the scope of the project is not affected, changes resulting in cost variations, changes of personnel assignments or schedule impact are considered changes to the project plan that may require authorization to implement.

Changes in the project cost must, under the proper circumstances have the approval of the Project Manager. Changes that result in cost variations or changes in the ETC for any WBS level 2 system greater than $100K must be initiated by a Change Request to the DØ PMG. Such Requests require the approval of the Associate Director for Research.

Baseline changes that result in changes to any milestones held by the Director of more than one month must be initiated by a Change Request submitted for consideration by the DØ PMG and approval by the Associate Director for Research. The response to such a Change Request may be to initiate a plan to reallocate resources to recover the schedule, a plan to stage or descope the detector or a plan to revise the project schedule objectives.

Baseline changes that result in an increase of the cost of personnel resources by more than 10% for any WBS level 2 system must be reported to the DØ PMG.

The DØ PMG will function as the Change Control Board for the project. Each Change Request will be reviewed by the DØ Project Manager. Subject to the above discussion, the Change Request will be forwarded to the DØ PMG for approval by the Associate Director for Research. The DØ Project Manager will maintain current records of all Change Requests and their disposition.

The following table summarizes the change control thresholds and responsibilities:

DØ Upgrade Project Change Control Thresholds

	FNAL Director/Deputy Director	DØ Upgrade Project Management
Technical	Changes that affect ES&H requirements or impact accelerator systems. Out-of-scope changes to upgrade physics capabilities.	Changes that do not affect ES&H requirements and do not change the upgrade project scope.
Cost	Any increase in the EAC greater than $100K for a WBS Level 2 system.	Any change in the EAC less than $100K for a WBS Level 2 system.
Schedule	Any change that results in the delay of a Director's milestone by more than one month.	Any change that results in the delay of an Upgrade Project Manager's milestone by more than one month.
Personnel	Any increase in personnel costs of more than 10% for a WBS Level 2 system.	Any change in personnel costs less than 10% for a WBS Level 2 system.

The thresholds that trigger changes to the project plan that require DOE approval are outlined in Sections 6 and 8 of the PEP. A summary may be found in Table 8.1 of that same document.

9 RISK MANAGEMENT ASSESSMENT

Detector upgrades are well within the experience and expertise of the D0 collaboration. Every effort has been made to specify these projects in a manner that reduces the level of risk to an acceptably low level. Several steps will be taken to assure that the risk to this project is low. A general discussion of risk may be found in Section 7 of the Acquisition Execution Plan for the RunIIb CDF and D0 Project (AEP).

9.1 Technical Risk

Preparation of clear and concise specifications, judicious determination of subcontractor responsibility and approval of proposed lower tier sub-subcontractors, and implementation of QA provisions will minimize technical risk. Projects have been designed to further minimize technical risk by exploiting previous experience to the greatest extent possible, and minimizing exposure to single vendor failures.

Making deliberately conservative design choices has minimized technically risky elements of the silicon detector. Use of single sided sensors, reduction in component variety, and common integrated circuit technologies will reduce risk. Similar considerations have been integrated into the design of the trigger upgrades, where efforts have been made to limit both the general scope and alternatives that would have resulted in extensive replacements of existing infrastructure. In all cases, the expertise of personnel involved in the design and implementation of previous versions of the silicon and trigger systems have been exploited to the fullest possible extent. Moreover, institutional commitments have been carefully crafted within the subprojects in order to help ensure timely and successful completion of the Project.

9.2 Cost Risk

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

9.3 Schedule Risk

As outlined in Section 7.3 of the AEP, schedule risk will be minimized via:

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

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

In addition, the Project will be tracked monthly, with schedule changes carefully monitored and approved through a change control process overseen by a combination of the Project Manager, the Laboratory Directorate, and DOE (see section 8 of this document).

9.4 Risk Analysis

Risk to the project will be evaluated by following a method outlined in A Guide to the Project Management Body of Knowledge. Two risk related quantities are estimated for each significant element of the project, an impact factor, and a risk probability. The impact factors are described in the following table.

Evaluating Impact of a Risk on Major Project Objectives					
Project Objective	**Very low 0.05**	**Low 0.1**	**Moderate 0.2**	**High 0.4**	**Very high 0.8**
Cost	Insignificant cost increase	< 5% Cost increase	5-10% Cost increase	10-20% Cost increase	> 20% Cost increase
Schedule	Insignificant schedule slippage	Schedule slippage < 5%	Overall Project slippage 5-10%	Overall Project slippage 10-20%	Overall Project slippage > 20%
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Project scope reduction unacceptable for physics objectives	Scope of project effectively useless for mission
Technical	Technical degradation of project barely noticeable	Technical performance of final product minimally affected	Technical performance of final product moderately affected	Degradation of technical performance unacceptable for physics objectives	Technical performance of end item effectively useless for mission

For each item within the project, an estimate will be made on the nature of the risk this item presents to the project as a whole. The impact for each of the four categories given in the table will be considered. The probability of occurrence (cost overrun, schedule slippage, etc.) will also be estimated. The product of these two quantities will is the risk factor. Mitigation strategies will be considered for any high risk items in the project, currently estimated as a risk factor of 0.18 or greater.

10 PROJECT CONTROLS SYSTEM

10.1 Introduction

This chapter summarizes the management systems that the Project will use to monitor the cost and schedule performance and the technical accomplishments of the Project. The significant interfaces that exist among the various management systems are noted in the individual narrative descriptions below. Although these systems are described separately they are mutually supportive and will be employed in an integrated manner in order to achieve the project objectives. As conditions change during the evolution of the project, the management systems will be modified appropriately so as to remain responsive to the needs for project control and reporting. Consequently, while the policy and objectives of each management system will remain fixed, the methods, techniques, and procedures that will be employed by the Project may change as conditions dictate, over the life of the project.

The Work Authorization and Contingency Management System and the Project Control System described in this chapter define the management and control procedures required by the Laboratory.

10.2 Guidelines and Policies

The Contingency Management System and the Project Control System employed by the Project will be consistent with the Fermilab "Project Control System Guidelines", dated May 1, 1994.

The following policies are applicable for the DØ Run IIb Upgrade:

- All Project work is organized in accordance with the WBS.
- Formal (and informal) reviews by experts are used to establish baseline specifications and designs.
- Established cost, schedule, and technical baselines are used for measuring project performance. Technical baselines are maintained in the Technical Design Reports describing the current design implementation for each system included in the scope of the Project.
- Changes to the approved cost, schedule and technical baselines proceed via a Change Request process described below.
- A project management system that features performance measurement based on cost accounting and scheduling is used to control the project and to provide forecast and feedback information to management. In particular, earned value will be calculated via the cost accounting tool COBRA, which uses as input the MS Project 2000 Run IIb Project schedule.
- The decision-making apparatus includes regular meetings among the Project Manager and the Subproject Managers. These meetings help to identify and resolve interface issues within the project.
- Quality assurance, safety analysis and review, and environmental assessment are integral parts of the Work Authorization and Project Control.

10.3 Work Authorization and Contingency Management

Funds will be made available by the Director to the Project on an annual basis following the receipt of the Initial Financial Plan from DOE. These funds will correspond to a financial plan and a funding profile to project completion as determined by the Director. The funding profile will include contingency in each year of the project.

Work packages will be established by the Fermilab Budget Office following the WBS structure. The accumulation of M&S costs in these accounts will be initiated through purchase requisitions originating with the engineering and scientific staff assigned to the various subsystems. Signature authority levels will be provided to the Fermilab Business Services Section by the Project Manager to assure that only authorized work is initiated.

At any time, the project contingency is the difference between the project Total Estimated Cost (TEC) and the Estimate at Completion (EAC). The Project Manager will hold the contingency and allocate it subject to the Project Control System described below.

The principles of contingency management that the Project will follow are as follows:

- The cost estimate for each subsystem will include contingency funds based on an assessment by the preparer, in conjunction with the PM, of uncertainties and risks associated with the budgeted cost;
- The actual expenditure of contingency will be reflected in a new EAC to be updated every six months;
- The Associate Director for Research will approve all Change Requests that will require utilization of contingency, subject to the thresholds levels below;
- All changes will be tracked with approved Change Requests and a record of all Change Requests will be maintained by the Project;
- Each fiscal year, the Project Manager will assign the contingency available in that year within the following guidelines:
    - The Project Manager may adjust the estimated cost of any WBS level 2 subproject by as much as $100K, as long as the Project TEC is not exceeded. If the change exceeds $100K, the Change Request must be approved by the Associate Director for Research;
    - The use of contingency above the amount budgeted for the year requires that a Change Request be approved by the Associate Director for Research.
- All changes from baseline cost shall be traceable.

10.4 Baseline Development

Baseline development includes management actions necessary to define project scope and responsibilities, establish baselines, and plan the project. Each upgrade subproject prepares a formal cost estimate and schedule. The subprojects all have defined Work Breakdown Structures (WBS) which are detailed subsets of the WBS, below level 3. In addition, technical specifications for each subproject are contained in the Technical Design Reports for the Silicon Tracker and the Trigger, the latter including the DAQ and Online systems.

10.5 Project Performance Measurement

Project Performance includes management actions after work commences that are necessary to monitor project status, report and analyze performance and available resources, and manage risk. Project performance aspects of the Project Control System consist of the following:

10.5.1 Funds Management

The detailed obligation plan for each WBS item is derived from the baseline schedule for the project that is funded at a rate consistent with the profile of funds from the Laboratory and other sources. This top-down obligation plan is adjusted by Project Management as appropriate to reflect changes in the Laboratory funding profile.

10.5.2 Accounting

A record of all M&S obligations associated with individual WBS elements is maintained in the Project financial system for tracking purposes. Each obligation is identified with the corresponding lowest-level WBS number(s), thereby enabling comparison of obligations with the Cost Estimate at any level. In this way, the usage of contingency is monitored item by item. Monthly tracking reports are produced that show all purchasing activity in each subproject, itemized by WBS number. For each item, as well as roll-ups to higher levels, the cost estimate, current-year allocation, year-to-date and project-to-date obligations and balances are displayed.

All Upgrade M&S transactions are also associated with Fermilab work packages, generally at WBS level 4. The Fermilab financial system is used to track and account for all obligations and subsequent costs at level 4 and above. Monthly accounting reports depict obligation and cost details and summaries for all work packages or WBS categories at and above level 4. The cost of labor in each WBS level 2 category in the Upgrade Project is captured by reporting the fraction of effort of each individual involved in the work and transferring the salary cost to the corresponding budget code.

The financial system accommodates the allocation of direct costs collected from a single point to multiple control accounts. This is accomplished through split coding. The split codes are tracked through the work packages in question and are reflected in the monthly reports.

10.5.3 Performance Measurement and Analysis

The principle functions of performance measurement and analysis are to identify, quantify, analyze and rectify significant deviation from the plan as early as possible. Earned-value reporting will be accomplished throught the use of the COBRA software package.

10.5.4 Schedule Variance

At the end of each month, the detailed schedule for each subproject is examined for variances from the baseline schedule. This is accomplished by updating the ‘actual’ schedule on the basis of work performed in the period, and comparing the actual schedule to the baseline schedule. An extensive set of milestones for each subproject is also monitored.

Changes that have a significant impact on the project, either by delaying completion or by affecting the cost or manpower plan of the project, are identified for further analysis. A plan to rectify the problem is developed that may include:

- alteration of the schedule to optimize the work and reduce the delay,
- allocation of additional resources (funds or manpower) to shorten the time required to perform given tasks.

Any change that would alter the schedule, cost or personnel resources of work to be performed is subject to the controls described below.

10.5.5 Cost Variance

In approving a purchase requisition, the WBS level 3 manager will compare the proposed obligation with the balances remaining for that item and its parents at higher levels. If the obligation does not exceed the estimated cost, the manager may approve the requisition directly. However, if the obligation would require use of contingency on that item or at a higher level, the manager must formulate a plan to fund the item and attach the details to the requisition for approval by the Project Manager. In this fashion, use of contingency is approved prior to incurring the obligation. Cost variances that exceed the established thresholds are formally reported as provided below.

Each month, obligation performance is determined by comparing obligations to date with budgeted or allocated costs to date as indicated by the obligation-loaded schedule.

10.5.6 Resource Variance

On a monthly basis, the available funds and manpower resources are compared with those required in the schedule to identify shortfalls that could lead to schedule and/or cost variances. Any such variances will be brought to the attention of the DØ PMG.

10.6 Change Management

Change management includes the actions necessary to ensure adequate control of project baselines, including the performance measurement baseline. Change Management aspects of the Project Control System consists of the following:

10.6.1 Out-of-Scope Changes

An out-of-scope change is a proposed change to the scope of the Laboratory-approved Project that would alter the physics capabilities of the detector in a major way or introduce a new detector system. The 'scope' of the project includes the design, construction and installation of the collection of systems or improvements to systems that have been granted Stage I approval by the Director. The scope of the project is defined by the proposal document that includes content equivalent to a Technical Design Report. Each individual system or an improvement to a system has an impact on the physics capability of the Project as a whole. This physics capability is also defined in the proposal. The scope of the project as an aggregate determines the physics capabilities of the upgraded detector.

Any out-of-scope change must be initiated by a formal proposal by the Spokespersons to the Director for consideration. In response to such a proposal, the Director may seek the advice of the Fermilab Physics Advisory Committee, the DØ PMG and/or a Director's Review. Such a proposal may be granted Stage I approval, deferred for further clarification of the physics potential, technique, cost and/or schedule, or it may be rejected.

10.6.2 In-Scope Changes

Any change to the Project that does not alter the scope of the Project as defined above does not require a new proposal to be submitted to the Laboratory. Although the scope of the project is not affected, changes resulting in cost variations, changes of personnel assignments or schedule impact are considered in-scope changes. The change management for in-scope changes is fully described in Chapter 8 on the mechanism for baseline change control.

10.7 Reporting and Review

10.7.1 Monthly Progress Reports

The Project provides reports on a regular basis to management. The objective of the reporting is to provide for the collection and integration of essential technical, cost, schedule and performance data into reports to aid in the monitoring and management of the Project.

All WBS Level 3 Managers submit monthly written reports to the Project Manager detailing specific progress on the pertinent subsystems. These reports summarize the activities of the previous month, describe activities planned for the upcoming month, and include comments and concerns. They are collected and summarized in a corresponding monthly report submitted to the Particle Physics Division Head and the Directorate that outlines progress, problems, and budget and schedule status, including comparisons of projected status versus actual status. The Directorate submits these reports to the DOE.

10.7.2 Technical Design Reports

A comprehensive Technical Design Report is written for each subsystem when the design of the system is sufficiently advanced that all significant issues and concerns have been resolved. This report is not a detailed engineering design, but a thorough discussion of all salient features of the detector or system and a rationale for key features and techniques. The report describes the plan for building the subsystem and the resources required. These reports, upon review and approval, become the technical baseline for the subsystems.

10.7.3 Meetings and Reviews

10.7.3.1 DØ Project Management Group (PMG)

Meeting convened by the Associate Director for Research to monitor the progress of the project, as described in Section 4.10.3.

10.7.3.2 DØ Upgrade Management Group

Regular weekly meetings between the Project Management and the Subproject Managers, as described in Section 4.10.2, will take place throughout the life of the project. Full discussion of all issues related to the status of the Project – technical, schedule, cost, personnel issues and needs – are covered here on a regular basis.

10.7.3.3 General Upgrade Meetings

Eight meetings each year, synchronized with Collaboration meetings held four times per year, for presentation of status reports, discussion of current issues and dissemination of news and information. These meetings are of general interest to anyone involved in the Project and serve to integrate diverse activities and provide an opportunity for physicists to criticize work in areas other than their own in this large project.

10.7.3.4 Subproject Meetings

Meetings called by Subproject Managers, typically bi-weekly, to discuss status, progress, and issues directly related to the pertinent subproject, as well as its coupling to other parts of the Project. It is here that the consensus of the experts is developed. Possible departures from schedule and cost, and their mitigation, are discussed in these meetings prior to a more general presentation to and discussion with the D0 Upgrade Management Group.

11 ACQUSITION STRATEGY PLAN

The acquisition strategy plan is detailed in the Acquisition Execution Plan for the Run IIb CDF and DØ Detector Projects. In the following sections we summarize some of those plans.

11.1 Construction and Fabrication

Fabrication of components and subsystems will be done in-house using Fermilab facilities, by outside vendors working under subcontract to the Laboratory, and by DØ collaborators at their home institutions. The responsibilities of each participating institution are further described in Memoranda of Understanding between the Project and the participating institution.

11.2 Procurement Plan

The components of the DØ Upgrade will be acquired in a manner consistent with DOE and general Fermilab guidelines. Whenever possible, fixed-price competitive procurement practices will be followed. Purchase requisitions will be processed by the Fermilab procurements group after appropriate approval.

11.3 Inspection and Acceptance

The Project Manager will be responsible for assuring that the appropriate procedures are in place at the subproject level to ensure that components and assemblies are inspected sufficiently to assure that they meet the technical specifications. The subproject manager is responsible for devising appropriate inspections. Acceptance of components and systems will be done by those directly responsible for them. When appropriate, inspection visits will be made to vendor shops and industrial firms fabricating or preparing components for the project.

11.4 System Testing and Commissioning

Once components are assembled and integrated into a subsystem, 'system tests' will be performed. These tests will involve the activation, debugging and tune-up of the full subsystem. Though such tests pertain to the system under study alone, they may require other subsystems to be operational to enable the tests. Examples of system tests include tests of the silicon tracker readout system and operation of the new trigger.

Commissioning consists of the process of integrating working subsystems into an operational experiment, and is the final stage of preparation for actual data-taking. At this stage one confronts interactions and potential conflicts between distinct detector, trigger and readout systems for the first time. The commissioning process will evolve gradually, as subsystems are assembled and system tests performed. Lastly, full operation of the upgraded detector in the Collision Hall will begin.

12 ALTERNATE TRADEOFFS

12.1 Silicon Tracker

The Collaboration has carefully studied two options for a Run IIb silicon tracker upgrade: "partial-replacement" and "full-replacement". In the partial-replacement option, the present tracker design would be retained and the inner two silicon layers would be replaced with new radiation-tolerant detectors. In the full replacement option, the Run IIa tracker would be replaced with a new device. A review of these two options by an internal committee appointed by the Spokespeople identified significant risks with the partial-replacement option, including the risk of damage to the components not being replaced, the long down-time required to retro-fit the existing detector, inadequate supply of SVX2 readout chips, difficulties in adequately cooling the inner layers, and marginal radiation hardness in the layers not being replaced. Furthermore, it is very difficult to re-optimize the partially-replaced detector for the Run IIb physics program. Therefore, DØ decided to proceed with the full-replacement option and build a new silicon tracker that is optimized for the Higgs search and other high-p_t physics processes.

12.2 Trigger Systems

The trigger systems primarily consist of electronics that must be integrated into existing systems within DØ. This constrains many of the designs. No specific alternate tradeoffs were considered, although details of the design have evolved continuously. The most limited set of upgrades to the trigger system needed to adequately address the physics goals in the high rate running environment of Run IIb has been chosen. In the interest of limiting the scope to that necessary for the physics program, a number of ancillary upgrades to the trigger were rejected early on as being unlikely to add sufficiently to the needed performance of the detector. Upgrades requiring broad replacements of infrastructure were reconsidered as well and, where possible, options chosen that limited such additional work. Much of these considerations were made in light of the tight schedule constraints that apply for Run IIb.

13 TECHNICAL CONSIDERATIONS

Technical considerations are presented and examined in detail as part of the Technical Design Reports for the Silicon and Trigger systems. A brief summary of the research and development considerations is presented below as well as the approach and responsibility for assurance of quality.

13.1 Research and Development

Subsystems and their components are designed to meet the requirements outlined in the TDR. Research and development is performed on detector components to ensure that the chosen technology will meet the physics and engineering requirements of the detector. Designs are documented in design reports and drawings are checked by peers, senior engineers, and/or managers. Design reviews are performed. Design reports, specifications, drawings and other documentation will be delivered to FNAL to ensure that detector components can be supported and maintained.

Technical considerations are presented and examined in detail as part of the Technical Design Report. A brief summary of the research and development considerations is presented below as well as the approach and responsibility for assurance of quality.

13.2 Quality Assurance Program

Quality Assurance is an integral part of the design, fabrication and construction of the DØ Upgrade. Special attention is paid to items that are most critical to the schedule and performance requirements of the Project. All work performed at Fermilab will draw on the guidelines and criteria set out in the Fermilab Quality Assurance Program (FQAP). These include:

- management criteria related to organizational structure, responsibilities, planning, scheduling, and cost control;
- training and qualifications of personnel;
- quality improvement;

- documentation and records;
- work processes;
- engineering and design;
- procurement;
- inspection and acceptance testing;
- assessment.

14 INTEGRATED SAFETY MANAGEMENT

This section describes the policies for ensuring that Environmental, Safety and Health (ES&H) considerations are adequately addressed within the DØ Run IIb project activities. The information below provides an overview of key issues. Policies, procedures and descriptive information are contained in the DØ ES&H Implementation Plan. ES&H is a line management responsibility and will be implemented down through the subsystem organizations.

14.1 Overview

Fermilab subscribes to the philosophy of Integrated Safety Management (ISM) for all work conducted on the Fermilab site and requires its subcontractor and sub-tier contractors to do the same. Integrated Safety Management is a system for performing work safely and in an environmentally responsible manner. The term "integrated" is used to indicate that the 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 work: quality, cost, and schedule. The seven principles of ISM are as follows:

(1) Line Management Responsibility for Safety: Line management is responsible and accountable for the protection of the employees, the public and the environment.

(2) Clear Roles and Responsibilities: The roles and responsibilities, and authority at all levels of the organization, including potential sub-tier contractors are clearly identified.

(3) Competence Commensurate with Responsibility: Personnel possess the experience, knowledge, skills and abilities that are necessary to discharge their responsibilities.

(4) Balanced Priorities: Resources are effectively allocated to address safety, programmatic and operational considerations. Protecting the public, the workers and the environment shall be a priority whenever activities are planned and performed.

(5) Identification of Safety Standards and Requirements: Before work is performed, the associated hazards are evaluated and an agreed upon set of safety standards and requirements are established which will provide adequate assurance that the public, the workers and the environment are protected from adverse consequences.

(6) Hazard Controls Tailored to Work Being Performed: Administrative and engineering controls, tailored to the work being performed, are present to prevent and mitigate hazards.

(7) Operations Authorization: The conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and understood by all.

The ES&H program at DØ is intended to ensure that all relevant and necessary actions are taken to provide a safe working environment at FNAL for the design, construction, installation, test, operation and decommissioning of the DØ detector. The DØ detector was designated a Low Hazard Radiological Facility and the Safety Envelope was approved in 1995. The Directorate, advised by the ES&H Section, will determine the need for updates or addenda to the DØ Safety Analysis Document.

14.2 Objectives

The following general objectives have been established by FNAL for the ES&H program for detectors:

- Establish and administer an ES&H program that promotes the accomplishment of FNAL ES&H objectives for employees and non-employees.
- Protect the general public and the environment from harm.
- Comply with federal, state and local laws, rules and regulations.

- Prevent personnel injury or loss of life during detector-related work.
- Prevent damage to equipment caused by accidents during detector-related work.
- Prevent any environmental contamination during detector development, fabrication, commissioning and operation.

14.3 Organization and Responsibilities

The ES&H program for the entire DØ Run IIb is the responsibility of the DØ Run IIb PM. The DØ Project Manager and his designees are responsible for establishing policies and requirements for ES&H during development and commissioning of the detector, and related experimental systems.

The DØ Project Manager has the responsibility for identifying specific ES&H issues and risks, and for ensuring that Subproject Managers establish appropriate safeguards and procedures for addressing those risks for each subproject. The Project Manager is responsible for ensuring that DØ Safety documentation is adequate for operating the upgraded detector. The Project Manager and the appointed Project Leaders are the laboratory line management on matters of environment, safety, and health for both the DØ Project and for operations aspects of the upgraded detector. The resources of the Particle Physics Division ES&H Department are also available to the Project Manager and Project Leader's upon request. Ad hoc ES&H review committees, reporting directly to the PPD Head, will be assigned as appropriate.

14.4 Documentation and Training

The DØ Project Manager is responsible for providing, as required, specific requirements and procedures, as well as hazard assessments, and other documents to comply with DOE and FNAL requirements. DØ ES&H documents are defined in the DØ Operations Guidelines Manual.

Those who are on the DØ project at the FNAL site will be provided with the training and information necessary to reduce the risks associated with their work and to ensure their safety. Briefings and presentations will be made to all managers and supervisors to communicate ES&H policies, documentation and information associated with assuring safety of DØ activities. Job-specific training will be provided on issues including electrical safety, cryogenic safety, radiation safety and chemical safety, as well as issues related to detector transportation, installation and testing activities. Proficiency testing is performed to gauge comprehension.

All visitors to DØ will be informed of FNAL ES&H rules and procedures applicable to their visit. In general, visitors will not be allowed to work in areas without the advance permission of the DØ Project Manager (PM) or his designee. All visitors to DØ must be accompanied by a Host who is familiar with FNAL and DØ ES&H rules and procedures. Hosts are responsible for the safety of the visitors they accompany.