# DRAFT
# Project Management Plan for the Run IIb D-Zero Detector Project

Fermilab

September 23, 2002

(This page intentionally left blank)

**Submitted, Approved, and Accepted By**:

**Run IIb D-Zero Detector Project Manager**

J. Kotcher

**D-Zero Collaboration Spokespersons**

G. Blazey

J. Womersley

**Department of Energy**

P. Philp
DOE Run IIb Project Manager

**Fermilab**

J. Cooper
Head of Particle Physics Division

H. Montgomery
Associate Director for Research

K. Stanfield
Deputy Director

M. Witherell
Director

(This page intentionally left blank)

# Project Management Plan
# for the
# Run IIb D-Zero Detector Project

## TABLE OF CONTENTS

# 1 INTRODUCTION

The Run IIb D-Zero Project Management Plan describes the physics, technical, cost, and schedule objectives for the Run IIb D-Zero Detector Project (Fermilab Experiment E925). It serves as a supplement to the "DOE Project Execution Plan for the Run IIb CDF and D-Zero Detector Projects" (the PEP), and provides further details specific to the D-Zero Detector Project.

## 1.1 Historical Background

The High Energy Physics (HEP) program of the Department of Energy (DOE) Office of Science conducts basic research into the nature and interactions of the fundamental constituents of matter. A major component of the US HEP program is the Fermi National Accelerator Laboratory (Fermilab) and its Tevatron Collider. The D-Zero (DØ) detector is one of two detectors that observe proton-antiproton collisions produced by the Tevatron Collider.

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). Over 100 $pb^{-1}$ of integrated luminosity were recorded in Run I, resulting 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.

The DØ Collaboration has successfully designed and constructed significant upgrades to the detector subsystems that, in concert with improvements to the Tevatron Collider, significantly extend the capabilities of the DØ detector. These improvements were designed for a peak luminosity of $2x10^{32}$ $cm^{-2}$ $sec^{-1}$ with 132 ns bunch spacing and a goal of accumulating 2 $fb^{-1}$ of integrated luminosity. In March 2001, the Collaboration began operation of the upgraded detected (Run IIa). The DØ upgrade for Run IIa also received CD-4 approval in March 2001.

## 1.2 The Run IIb D-Zero Detector Project

The purpose of the Run IIb D-Zero Detector Project is to design and construct further improvements to the DØ detector needed to accumulate ~15 $fb^{-1}$ of integrated luminosity. Beginning in CY 2000, an effort has been underway at DØ to specify these improvements. Collectively, they are referred to as the Run IIb D-Zero Detector Project (the Project) and are the subject of this Project Management Plan. The principal elements of the Project are: (a) replacement of the silicon detector; (b) upgrades of the Level 1 and Level 2 trigger systems; and (c) DAQ and online computing upgrades. A detailed technical description of the Project can be found in the DØ Technical Design Report[1]. The goal of these improvements is to meet the scientific objectives described in section 2.1, including a sensitive search for the Higgs Boson. The timeframe for the Project is to begin construction in CY 2003 and complete the project in CY 2006.

---

[1] DØ Technical Design Report, http://d0server1.fnal.gov/projects/run2b/Docs/TDR/D0_Run2b_TDR.pdf.

### 1.3 Overview of this Document

This document describes the Run IIb D-Zero Detector Project, the project objectives, organization, management, and review mechanisms. The document supplements the PEP by providing additional details specific to the management of the DØ project. Section 2 describes the mission justification, including scientific, technical, cost, and schedule objectives. The following sections describe the detailed Project objectives, 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

This section describes the scientific, technical, cost, and schedule objectives that define and justify the mission and goals of the project.

## 2.1 Scientific Objectives

The purpose of the project is to provide technical components to upgrade the DØ detector to enable it to accumulate sufficient integrated luminosity to maximize the chance for discovering the Higgs Boson. The Higgs Boson is thought to be responsible for breaking the Electro-Weak symmetry, giving rise to particle masses. Understanding the mechanism for Electro-Weak Symmetry Breaking has been identified as the highest priority of the US High Energy Physics (HEP) program in the recent sub-panel report commissioned by the High Energy Physics Advisory Panel (HEPAP) to assess the long-range future of the field. There are strong indications that the Higgs mass is likely to be within the range where the DØ detector is sensitive to it provided the detector collects sufficient integrated luminosity.

The Fermilab Tevatron provides the highest energy particle beams in the world, enabling unique opportunities for scientific discovery. Fermilab will continue to operate at the "Energy Frontier" until the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) begins operation with much higher beam energy. Initial LHC operation will occur in late FY2007 at the earliest, providing the Fermilab Tevatron Collider a window of opportunity for making a major scientific discovery. Estimates indicate that, due to radiation damage, the current silicon detectors will only be useful up to 4 $fb^{-1}$, which is expected to occur in about 2005. The detector components provided by the Run IIb upgrade will allow DØ to operate at high luminosity and meet the laboratory's goal of acquiring an integrated luminosity of 15 $fb^{-1}$. This is a significant increase above the Run IIa goal of 2 $fb^{-1}$ and will greatly increase the sensitivity of the experiment.

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 foci will include the search for the Higgs particle(s) at masses up to ~180 GeV, searches for new phenomena beyond those predicted by the "Standard Model" of particle physics, 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 scientific objectives require that characteristic objects be detected and identified at angles more than 15 degrees from the beams, and that the energies of the objects be well determined. The primary objects of interest are electrons, photons, muons, bottom quark particles, and quark/gluon jets. The presence of neutrinos and other non-interacting particles are also inferred from the detector measurements.

## 2.2 Technical Objectives

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 approximately 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 scientific and technical objectives for Run IIb, the following upgrades are necessary:

- The current silicon tracker must be replaced with a device that is capable of handling the radiation associated with 15 $fb^{-1}$ of integrated luminosity that is expected in Run IIb.
- 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 $p\bar{p} \to ZH \to b\bar{b}\,\nu\bar{\nu}$ .
- 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.

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 Project consists of the silicon tracker replacement, trigger upgrades, and the equipment portion of the DAQ/online upgrade. The installation and commissioning of the Run IIb detector components and DAQ/online computing operating costs are not funded by the Project, but are being managed and overseen as an integrated part of the Run IIb effort.

Subsystem requirements are derived from the following operational goals for the DØ detector to be achieved after installation and commissioning of the Project:

- The tracking system must record the trajectories of charged particles from proton-antiproton collisions with greater than 95% efficiency. 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 from high momentum electrons and muons for use in event reconstruction and 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.
- 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 good efficiency within the 5 kHz, 1 kHz, and 50 Hz bandwidth budget for 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 10% dead time for the experiment. The recording rate of interesting events to permanent media and subsequent analysis should be approximately 50 events per second, with capacity for a peak recording rate of 100 events 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.

A Technical Design Report[1] has been prepared that provides a detailed technical description of the Project.

### 2.3 Cost Objectives

The estimated total project cost is summarized Table 7.3 of the PEP. The funding plan for the Project is summarized in Table 6.1 of the PEP. In addition to support from the DOE, the funding plan includes contributions from DØ 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 7.4 of the PEP. The most critical milestone has the silicon detector, which paces the project, ready for installation in the bore of the DØ Detector in the collision hall at the end of calendar year 2006. The trigger and DAQ/online computing upgrades are expected to be ready for installation in advance of the silicon detector, and are not expected to drive the project completion date.

# 3 PROJECT DESCRIPTION

The detailed Project description is provided in the Technical Design Report[1]. In the following sections we describe, in brief, the main elements of the upgrade and provide a brief description of the work that needed to build the upgraded detector. We note that the Run IIa calorimeter, muon, and fiber tracker detector systems will be used in Run IIb without modification.

## 3.1 Silicon Detector

The current DØ silicon detector was built to withstand the 2-4 $fb^{-1}$ of integrated luminosity originally projected for Run II. The higher integrated luminosity expected in Run IIb will render the inner layers of the present detector inoperable due to radiation damage. Of particular importance for the collection of the data needed for timely Higgs discovery is completion of the replacement detector in approximately three years with minimal Tevatron down time. The new detector 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 2304 silicon sensors, 7440 SVX4 readout chips, and a total of 952K 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 (~7 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 $4\text{-}5 \times 10^{32}\ cm^{-2}sec^{-1}$) and possibly shorter bunch spacing (132 nsec) expected in Run IIb. An increase in the Level 1 trigger rejection by a factor of 3-4 is required to meet the Level 1 trigger rate requirement. This increase in trigger rejection will be achieved through changes to the Level 1 calorimeter and track triggers. The Level 1 Calorimeter Trigger will be replaced with new trigger hardware that provides digital filtering of the calorimeter signals and utilizes more sophisticated trigger algorithms to sharpen trigger thresholds and increase trigger rejection. The Level 1 Central Track Trigger will be modified to incorporate more powerful Field Programmable Gate Arrays (FPGAs) that utilize fiber singlets, as opposed to the currently used doublets, to increase trigger rejection. A new Level 1 Cal/Track Match system will provide a spatial match of candidate tracks with calorimeter energy depositions to further increase trigger rejection.

The Level 2 trigger must maintain the trigger rejection in the current design while receiving more complicated events due to the higher luminosity in Run IIb and the increase in the Level 1 trigger rejection. The Level 2β trigger processors will be replaced with higher performance processors that will allow the use of more sophisticated algorithms. The Level 2 Silicon Track Trigger (STT) will be extended from four to five layers to maintain trigger rejection at high luminosity with the new silicon detector.

The Level 3 trigger must also maintain the trigger rejection in the current design while receiving more complicated events due to the higher luminosity in Run IIb and the increase in the Level 1 and Level 2 trigger rejection. This will be accomplished by adding 96 additional processing nodes to the Level 3 Linux filter farm to allow the use of more sophisticated filter algorithms. The Level 3 trigger is tightly integrated with the DAQ/online computing systems and is managed in the Project as an element of these systems.

### 3.3 DAQ/Online Computing

The DAQ/online computing system is comprised of all the computer equipment and software required to readout, monitor, and control the experiment. It includes subsystems to readout the detector and make the Level 3 trigger decision, 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.

### 3.4 Installation

A separate WBS Level 2 element has been called out for Run IIb installation and commissioning to enable the development of an organized, integrated plan that will be used to smoothly transition DØ from completion of the Run IIb D-Zero Detector Project through installation to data-taking readiness. The installation of 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.

### 3.5 R&D Program

The research and development effort associated with the Project officially started in 2000 with the formation of a DØ Run IIb working group that largely focused on upgrade options for the silicon detector. A series of trigger workshops was also 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 designed and fabricated by Fermilab, collaborating institutions, and outside vendors. R&D work also continues on the trigger and DAQ/online systems, providing concrete input to the corresponding project plans. Of particular note is the design and fabrication of prototype Level 1 calorimeter trigger ADF boards, scheduled for completion in early CY 2003 with in-situ testing of these boards at DØ shortly thereafter.

# 4 MANAGEMENT, ORGANIZATION, AND RESPONSIBILITIES

## 4.1 Overview

The 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 capabilities of the Tevatron 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 organization chart (Figure 1) and are described in the following sections of this chapter.

## 4.2 Department of Energy

The Department has established the need for the 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 Project. These funds are provided through the annual Fermilab 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 Project 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 and performance measures.

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

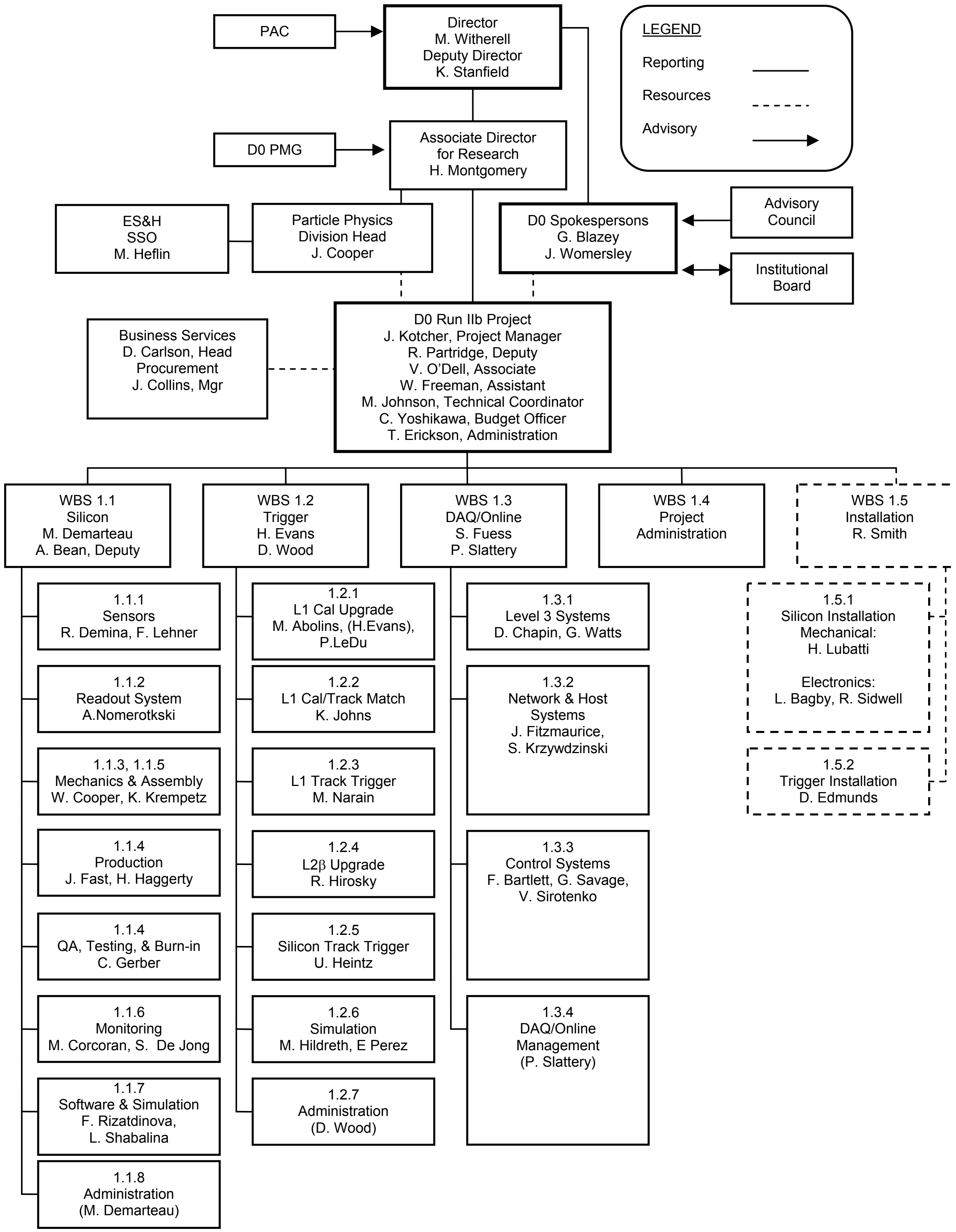


Figure 1. Organization chart for the Run IIb D-Zero Detector Project.

### 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 Project and only he is authorized to commit funds appropriated for Laboratory use. The Director approves the scope of the 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 Report (TDR), the Project Management Plan (PMP), the cost estimate, the schedule, the financial plan, and changes in scope for the Project.

### 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 (section 4.13.2) 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, Run IIb Memoranda of Understanding are executed with collaborating institutions. The Associate Director for Research approves all Run IIb 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 TDR, PMP, cost estimate, schedule, and 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 provides oversight for PPD financial resources, human resources, technical resources, space resources, and Environmental, Safety, and Health (ES&H) monitoring for the Project.

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 Run IIb 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 manpower directly to the project in consultation with the Project Manager and in accordance with the CSP. The Project Manager then deploys 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.

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 Run IIb Memoranda of Understanding. The PPD Head maintains direct line management responsibility for such PPD resources.

Since the PPD 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 Fermilab Particle Physics Division Senior Safety Officer

The PPD Senior Safety Officer (SSO) reports to the PPD Head and is responsible for ES&H issues in PPD. The SSO is part of the ES&H line management responsibility for the Project (see section 14).

### 4.7 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 Run IIb D-Zero Detector Project. The Spokespersons are elected by the Collaboration. In doing so, the Collaboration consults with the Director and he concurs in the selection.

### 4.8 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, ES&H, administration, financing, and scheduling.

The Project Manager has the responsibility of completing the Project on schedule, on budget, and within the agreed upon scope by managing the resources of the Laboratory and, in consultation with the Spokespersons, the resources of the Collaboration. 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 on all matters related to managing the Project to the approved scope, cost, and schedule. He reports to the Associate Director for Research on all matters that 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, the Project Manager reports to the Spokespersons and also identifies the need to the Director through the PMG. Other changes follow the change control procedure in section 8.

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 speaks 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.

The Project Manager is part of the ES&H line management responsibility for the Project (see section 14).

### 4.9 Deputy, Associate, and Assistant Project Managers

The Deputy Project Manager, Associate Project Manager, and Assistant Project Manager are appointed by the Project Manager with the concurrence of the DØ Spokespersons. They assist the Project Manager in the management of the Project and report to the Project Manager.

### 4.10 Technical Coordinator

The Technical Coordinator is appointed by the Project Manager with the concurrence of the DØ Spokespersons. The Technical Coordinator reports to the Project Manager and assists the Project Manager in the coordination, evaluation, and decision-making process for technical issues in the Project.

### 4.11 DØ Upgrade Subproject Managers

DØ Upgrade Subproject Managers are appointed by the Project Manager, with the concurrence of the Spokespersons, for each WBS Level 2 and Level 3 subproject. 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. The Subproject Managers are part of the ES&H line management responsibility for the Project (see section 14).

### 4.12 DØ Collaborator Responsibilities

The responsibilities of DØ Collaborators are specified in comprehensive Run IIb Memoranda of Understanding (MoU). A multi-year MoU details the work that the Collaborator has agreed to do for the Project, and includes a list of the personnel involved, and significant milestones. These agreements are updated yearly through Statements of Work (SOW) that specify the funding and commitments for the next Fiscal Year. They are approved by the Collaborator DØ Contact Person, appropriate responsible parties for the collaborating institution, 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 SOW's. These documents are components of the Work Plan for the project and, as such, are considered part of the PMP.

### 4.13 Advisory Functions

#### 4.13.1 DØ Upgrade Managers Group

The Project Manager chairs the DØ Upgrade Managers Group that meets as required to discuss technical and management issues in the Project and is advisory to the Project Manager. The meetings also provide a convenient mechanism for the dissemination of information. The group is comprised of the Spokespersons, Project Manager, Deputy, Associate, and Assistant Project Managers, Technical Coordinator, the WBS Level 2

Subproject Managers, additional personnel from the Project Office, and others as the need arises. The WBS Level 3 Subproject Managers often participate in these meetings.

#### 4.13.2 DØ Project Management Group

The Associate Director for Research chairs a Project Management Group (PMG) that meets as required to monitor the progress of the project. The meetings are 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 also serves as the Change Control Board for the project.

#### 4.13.3 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 for election and the conduct of spokesperson elections; the selection of the chair of the institutional board; and, under exceptional circumstances, calls for special Spokesperson elections.

#### 4.13.4 DØ Finance Committee

The DØ Finance Committee consists of a DØ physicist and a funding agency representative for each agency funding DØ. Since the U.S. contribution comes through Fermilab, the Fermilab Associate Director of Research is 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 upgrades to the detector.

# 5 WORK BREAKDOWN STRUCTURE

All work required for completion of the Project is organized into a hierarchical 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 foundation of the WBS for the technical components is Technical Design Report[1]. The WBS is expressed through a resource-loaded schedule with appropriately linked tasks. The schedule contains Materials and Services (M&S) costs, labor costs, and contingency on a task-by-task basis, as well as a series of project milestones which aid in the estimation of the project end date. The WBS structure to level 3 is shown in the organization and reporting chart in section 4.

The major systems that comprise the Project are represented at WBS Level 2 as the Silicon Detector (1.1), the Trigger Upgrade (1.2), and the DAQ/Online Computing (1.3). There is an additional WBS Level 2 item for Administration (1.4). While not part of the Project, a WBS Level 2 item for Installation (1.5) is included to aid in tracking this related activity. The task-based WBS extends downward through many additional levels to facilitate cost, schedule and resource planning. The WBS structure through Level 3 is described below.

WBS 1 Run IIb D-Zero Detector Project
This Level 1 summary element consists of all elements of the Project: Silicon Detector, Trigger Upgrade, DAQ/Online Computing, and Administration. It also includes the associated Installation element.

WBS 1.1 Silicon Detector
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, readout electronics, mechanical supports, module production, assembly, monitoring, software, and associated administration.

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 Design and Fabrication

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 Detector Production and Testing

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 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 the DØ 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 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 refined.

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 increased luminosity, the three level trigger system at DØ requires upgrading. This summary element includes improvements to the Level 1 and Level 2 triggers.

WBS 1.2.1 Level 1 Calorimeter Trigger

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 Level 1 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 trigger cards, and procurement of related cabling, connectors, readout crates, processors, and power supplies.

WBS 1.2.3 Level 1 Tracking

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 Processor

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 Upgrade

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 Trigger 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 Online Systems

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.

WBS 1.3.1 Level 3 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 Systems

This summary element contains upgrades that pertain to the EPICS-based control system infrastructure.

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 Run IIb Project Administration

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

WBS 1.4.1 FY03

Administration expenses incurred in FY03.

WBS 1.4.2 FY04
Administration expenses incurred in FY04.

WBS 1.4.3 FY05
Administration expenses incurred in FY05.

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.

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 trigger racks, and the installation, cabling, and technical commissioning of all trigger, DAQ, and online electronics subsystems.

# 6 RESOURCE PLAN

The planned funding profile for the Project can be found in Table 1. It includes all sources of funding including those from DOE, DØ collaborators, and NSF MRI funding. All foreign sources are in-kind contributions applied toward the trigger from non-US collaborators. Two Major Research Instrument (MRI) grants have been awarded by National Science Foundation that provide partial funding for the silicon detector and the trigger upgrade, with spending having begun for the silicon MRI. U.S. Universities support is from in-kind support of engineering and other technical personnel. DOE funding in FY06 is used for payback of forward funding by U.S. Universities in FY03.

Table 1. Planned funding profile for the Run IIb D-Zero Detector Project.

| | **Planned Funding (AY dollars in thousands)** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | **FY01** | **FY02** | **FY03** | **FY04** | **FY05** | **FY06** | **Total** |
| DOE Equipment | 0 | 3,500 | 4,131 | 8,588 | 5,832 | 2,354 | 24,406 |
| DOE R&D | 0 | 1,499 | 1,000 | 0 | 0 | 0 | 2,499 |
| Foreign sources | 0 | 258 | 267 | 70 | 1 | 0 | 597 |
| NSF–MRI silicon | 17 | 1,326 | 811 | 306 | 0 | 0 | 2,460 |
| NSF–MRI trigger | 0 | 0 | 114 | 474 | 0 | 0 | 588 |
| U.S. Universities | 0 | 194 | 153 | 30 | 43 | 0 | 420 |
| Forward funding | 0 | 0 | 2,000 | 0 | 0 | (2,000) | 0 |
| **Total Funding** | **17** | **6,777** | **8,477** | **9,468** | **5,876** | **354** | **30,970** |

# 7 TECHNICAL, SCHEDULE, AND COST BASELINES

## 7.1 Technical Baseline and Technical Definition of Project Completion

The technical baseline for the Project is described in the Technical Design Report[1]. The technical definition of Project Completion for the Project is listed in Table 2. Since installation of the technical components into the DØ detector is not part of the Project, Project Completion is based upon verifying the functionality of the Run IIb detector components prior to installation into the detector.

Table 2. Technical definition of Project Completion.

| Subsystem | Technical Definition of Completion |
|---|---|
| Silicon Detector | System test with successful readout of five staves. |
| Level 1 Trigger | Level 1 Trigger boards assembled and bench-tested using simulated inputs to verify boards meet design specifications. |
| Level 2 beta | Processors procured and input/output tested for correct beta-to-beta communication in a test crate. |
| Level 2 Silicon Track Trigger | Silicon Track Trigger boards assembled and bench-tested using simulated inputs to verify boards meet design specifications. |

## 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 employers. 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 labor cost for 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 are then derived. Using this information, a consistent and viable work plan is 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 describes the foundation of and justification for the resources assigned to each task in the schedule. Cost Books have been prepared that provide the source documentation (quotes, invoices, etc.) and supplementary information used in preparing the BOE.

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

A 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 hierarchical set of milestones have been established to track progress in the Project. At the lowest level (Level 4), a comprehensive set of milestones are distributed throughout the duration of each subproject, with the Subproject Managers holding change control authority for the Level 4 milestones. A subset of the Level 4 milestones is selected to serve as Level 3 milestones; the Project Manager monitors and holds change control authority for the Level 3 milestones. The Level 2 milestones are derived from a subset of Level 3 milestones; the Director and the DOE Run IIb Project Manager monitor and hold change control authority for the Level 2 milestones. These “Director’s Milestones” are listed in Table 5 below. The Level 1 milestones are derived from a subset of the Level 2 milestones; the DOE Acquisition Executive monitors and holds change control authority for the Level 1 milestones as described in the PEP. The Level 1 milestones are listed in Table 4 below. The Level 0 milestones represent the Critical Decisions for the project; the DOE Deputy Secretary monitors and holds change control authority for the Level 0 milestones as described in the PEP. The Level 0 milestones are listed in Table 3 below.

Table 3. Level 0 milestones for the Run IIb D-Zero Detector Project.

| No. | Milestone | Date |
|---|---|---|
| 0.0 | CD-0: Approve Mission Need | 5/01 |
| 0.1 | CD-1: Approve Preliminary Baseline | 11/02 |
| 0.2 | CD-2: Approve Performance Baseline | 11/02 |
| 0.3 | CD-3: Approve Start of Construction | 11/02 |
| 0.4 | CD-4: Approve Project Closeout | 11/06 |

Table 4. Level 1 milestones for the Run IIb D-Zero Detector Project.

| No. | Milestone | Date |
|---|---|---|
| 1.1 | All Silicon Sensors Delivered and Tested | 7/05 |
| 1.2 | Level 2 Trigger Production and Testing Complete | 3/06 |
| 1.3 | Silicon Stave Production Complete | 4/06 |
| 1.4 | Level 1 Trigger Production and Testing Complete | 4/06 |
| 1.5 | Online System Production and Testing Complete | 7/06 |
| 1.6 | Silicon Ready to Move to DZero Assembly Building | 11/06 |

Table 5. Level 2 Director's Milestones for the Run IIb D-Zero Detector Project. The milestones shown in red have corresponding Level 1milestones listed in Table 4 above.

| No. | Milestone | Date |
|---|---|---|
| | **Silicon** | |
| 2.1 | Silicon Prototype Mechanical Stave Built | 12/27/02 |
| 2.2 | L2-L5 Silicon Sensors Released For Production | 3/3/03 |
| 2.3 | SVX4 Released For Production | 6/27/03 |
| 2.4 | Successful Readout Of Full Silicon Stave | 11/23/03 |
| 2.5 | Silicon Module Production Begun | 3/22/04 |
| 2.6 | All SVX4 Chips Produced And Tested | 6/27/04 |
| 2.7 | All Silicon Hybrids Produced And Tested | 10/8/04 |
| 2.8 | Silicon Stave Production Begun | 10/20/04 |
| 2.9 | All Silicon Sensors Delivered And Tested | 10/26/04 |
| 2.10 | Silicon Module Production And Testing Complete | 2/20/05 |
| 2.11 | Downstream Silicon Readout Ready for Installation On Platform | 4/24/05 |
| 2.12 | Silicon Stave Production Complete | 7/24/05 |
| 2.13 | South Silicon Complete | 10/27/05 |
| 2.14 | North Silicon Complete | 12/6/05 |
| 2.15 | Silicon Ready To Move To DAB | 12/26/05 |
| | **Trigger** | |
| 2.16 | L1 Trigger Cal-Trk Match Production and Testing Completed | 9/26/04 |
| 2.17 | L2 Silicon Track Trigger Production and Testing Complete | 3/8/05 |
| 2.18 | L1 Calorimeter Trigger Production And Testing Complete | 5/15/05 |
| 2.19 | L2 Beta Trigger Production And Testing Complete | 6/7/05 |
| 2.20 | L2 Trigger Upgrade Production and Testing Complete | 6/25/05 |
| 2.21 | L1 Central Track Trigger Production And Testing Complete | 7/13/05 |
| 2.22 | L1 Trigger Upgrade Production and Testing Complete | 7/13/05 |
| | **Online** | |
| 2.23 | Online System Production and Testing Complete | 10/6/05 |

### 7.3 Manpower Requirements

The manpower requirements are extracted from the schedule and are given in Table 6 in units of person-years. The categories shown include all collaboration-wide physicist manpower (Physicist), technical manpower provided by collaborating institutions (Technical-University), and technical manpower provided by Fermilab (Technical-Fermilab). Note that physicist manpower is funded by non-Project sources and is not included in the Project cost.

Table 6. Staffing plan for physicist and technical manpower. Units are person-years.

| | Prior Yrs | FY 2003 | FY 2004 | FY 2005 | Total |
|---|---|---|---|---|---|
| Physicist | 16.3 | 31.6 | 34.8 | 10.6 | 93.3 |
| Technical-University | 5.6 | 10.8 | 7.8 | 1.5 | 25.7 |
| Technical-Fermilab | 5.6 | 10.8 | 7.8 | 1.5 | 25.7 |
| **DØ Total** | **27.5** | **63.4** | **65.3** | **18.6** | **174.8** |

## 7.4 Project Cost

The cost estimate for the Project covers all Materials & Services (M&S) and Salaries, Wages and Fringe Benefits (SWF) costs for the Project. It does not include the operating costs for the DAQ/online system or the costs for installation of the Run IIb detectors.

### 7.4.1 Cost Estimate

The M&S costs and labor resources are estimated at the lowest (task) level in the Project Schedule. Contingency for labor and M&S is also estimated at the task level based on the guidelines described in sections 7.4.2 and 7.4.3. 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, and

- 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.

#### 7.4.4 Cost Summary

The Total Project Cost (TPC) for the Run IIb D-Zero Detector Project in AY dollars is $30,970K, including $10,814K in contingency. A breakdown of the Project Cost in AY dollars at WBS Level 3 is presented in Table 7. An obligation profile showing the anticipated obligations by fiscal year is extracted from the schedule. Table 8 shows the obligation profile for the Project at WBS Level 2 with R&D and contingency broken out from the subsystem costs.

Table 7. Project costs in AY dollars at WBS Level 3 for the Run IIb D-Zero Detector Project.

| WBS | Description | Base k$ | Contingency k$ | Contingency % | Total k$ |
|---|---|---|---|---|---|
| **1.1** | **Silicon Detector** | **14,757** | **8,178** | **55** | **22,935** |
| 1.1.1 | Sensors | 3,119 | 1,356 | 43 | 4,475 |
| 1.1.2 | Readout System | 6,610 | 3,863 | 58 | 10,473 |
| 1.1.3 | Mechanical Design and Fabrication | 1,431 | 982 | 69 | 2,413 |
| 1.1.4 | Detector Production and Testing | 1,264 | 933 | 74 | 2,197 |
| 1.1.5 | Silicon Barrel Assembly | 1,810 | 797 | 44 | 2,606 |
| 1.1.6 | Monitoring | 106 | 54 | 51 | 160 |
| 1.1.7 | Software and Simulation | 18 | 0 | 0 | 18 |
| 1.1.8 | Administration | 399 | 194 | 49 | 592 |
| **1.2** | **Trigger** | **3,189** | **1,540** | **48** | **4,728** |
| 1.2.1 | Level 1 Calorimeter Trigger | 1,557 | 714 | 46 | 2,271 |
| 1.2.2 | Level 1 Calorimeter Track-Matching | 279 | 117 | 42 | 396 |
| 1.2.3 | Level 1 Tracking | 978 | 505 | 52 | 1,483 |
| 1.2.4 | Level 2 Beta Processor | 105 | 85 | 81 | 190 |
| 1.2.5 | Silicon Track Trigger Upgrade | 264 | 115 | 44 | 379 |
| 1.2.6 | Trigger Simulation | 0 | 0 | 0 | 0 |
| 1.2.7 | Administration | 6 | 3 | 51 | 9 |
| **1.3** | **Online Systems** | **1,014** | **489** | **48** | **1,503** |
| 1.3.1 | Level 3 Systems | 273 | 191 | 70 | 464 |
| 1.3.2 | Network and Host Systems | 495 | 200 | 41 | 695 |
| 1.3.3 | Control Systems | 228 | 80 | 35 | 308 |
| 1.3.4 | DAQ/Online Management | 18 | 18 | 100 | 36 |
| **1.4** | **Run IIb Project Administration** | **1,197** | **607** | **51** | **1,803** |
| 1.4.1 | FY03 | 400 | 203 | 51 | 603 |
| 1.4.2 | FY04 | 399 | 202 | 51 | 601 |
| 1.4.3 | FY05 | 398 | 201 | 51 | 599 |
| **1** | **TOTAL PROJECT COST** | **20,156** | **10,814** | **54** | **30,970** |

Table 8. Obligation profile for the Run IIb D-Zero Detector Project.

| Obligation Profile (AY dollars in thousands) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | **FY01** | **FY02** | **FY03** | **FY04** | **FY05** | **FY06** | **Total** |
| Silicon Detector | 17 | 1,326 | 6,171 | 4,034 | 709 | 354 | 12,611 |
| Trigger | 0 | 453 | 1,040 | 1,561 | 109 | 0 | 3,163 |
| Online Systems | 0 | 0 | 64 | 331 | 619 | 0 | 1,014 |
| Administration | 0 | 0 | 385 | 399 | 413 | 0 | 1,197 |
| Sub Total | 17 | 1,778 | 7,660 | 6,325 | 1,850 | 354 | 17,985 |
| R&D | 0 | 1,376 | 795 | 0 | 0 | 0 | 2,171 |
| Contingency | 0 | 0 | 3,645 | 3,143 | 4,026 | 0 | 10,814 |
| **Total Project Cost** | **17** | **3,154** | **12,100** | **9,468** | **5,876** | **354** | **30,970** |

# 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.

## 8.1 Change Control Procedures

Formal change control procedures will be used to track technical, schedule, and cost changes in the Project. Each such change requires the preparation of a Change Request form. Each Change Request will be reviewed by the Project Manager. The DØ PMG will function as the Change Control Board for the project. Subject to the change control levels described below, the Change Request may 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.

## 8.2 Technical Change Control Levels

Minor technical changes consistent with the baseline technical design must be approved by the Subproject Manager.

Major technical changes that are a significant departure from the baseline technical design must be approved by the Project Manager.

Technical changes that affect ES&H requirements, impact accelerator systems, or changes in scope that affect physics capabilities require a Change Request be submitted for consideration by the DØ PMG and approved by the Associate Director for Research.

## 8.3 Schedule Change Control Levels

Changes that result in the delay of a Level 4 milestone by more than a month must be approved by the Subproject Manager.

Changes that result in the delay of a Level 3 milestone by more than a month must be approved by the Project Manager.

Changes that result in the delay of a Level 2 Director's Milestones require a Change Request be submitted for consideration by the DØ PMG and approved by the Associate Director for Research and the DOE Run IIb Project Manager. 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 rescheduling of the milestone.

## 8.4 Cost Change Control Levels

Changes to the cost of a single item exceeding $10K must be approved by the Subproject Manager.

Changes to the cost of a single item exceeding $50K or a 10% increase in the Subsystem base cost during the previous 12 months must be approved by the Project Manager.

Changes in the cost of a single item exceeding $250K or a $1.5M increase in the project base cost during the previous 12 months require a Change Request be submitted for consideration by the DØ PMG and approved by the Associate Director for Research.

## 8.5 Change Control Summary

Table 9 summarizes the Fermilab change control thresholds and responsibilities. Table 10 summarizes the DOE change control thresholds and responsibilities described in the PEP. Figure 2 shows a sample Change Request form.

Table 9. Fermilab technical, schedule, and cost baseline control levels.

| | **Fermilab Deputy Director** | **DØ Project Manager** | **Subproject Manager** |
|---|---|---|---|
| Technical | Changes that affect ES&H requirements or impact accelerator systems. Out-of-scope changes to upgrade physics capabilities. | Major technical changes that are significant departures from the baseline technical design. | Minor technical changes that are consistent with the baseline technical design. |
| Schedule | Any change that results in the delay of a Level 2 Director's milestone. | Any change that results in the delay of a Level 3 milestone by more than one month. | Any change that results in the delay of a Level 4 milestone by more than one month |
| Cost | Increase in the cost of a single item by more than $250K. Increase in the Project base cost exceeding $1.5M during the previous 12 months. | Increase in the cost of a single item by more than $50K. Increase in a subsystem base cost exceeding 10% during the previous 12 months. | Increase in the cost of a single item by less than $10K. |

Table 10. DOE technical, schedule, and cost baseline control levels from the PEP.

| | **Deputy Secretary (Level 0)** | **Acquisition Executive (Level 1)** | **DOE Run II Project Manager (Level 2)** |
|---|---|---|---|
| Technical | Decrease in scope to maintain cost. | Changes to scope that affect mission need. | |
| Schedule | Any change to level 0 milestones. | Any change to level 1 milestones. | Any change to level 2 milestones (see PMPs). |
| Cost | Any increase in TEC (TPC will be controlled via the PMPs). | | Any use of contingency that would take the contingency as a percentage of ETC below 35%. |

| 1) DATE: | 2) WBS NUMBER: | 3) ORIGINATOR: |
|---|---|---|
| 4) TITLE OF CR & MASTER LOG NUMBER: | | |

5) WBS DESCRIPTION OF PRIMARY AFFECTED TASKS:

6) TECHNICAL DESCRIPTION AND PRIMARY MOTIVATION OF CHANGE (technical, cost, schedule, or other; include interfaces with other areas and use attachments, as necessary):

7) ASSESSMENT OF COST IMPACT:

| | --------Before CR-------- | | --------After CR-------- | | -----------Delta (+/-)----------- | | Total Cost |
|---|---|---|---|---|---|---|---|
| WBS | M&S | Labor | M&S | Labor | M&S | Labor | G&A/Esc | Increase |

Run IIb Budget Officer Concurrence ________ Initial / Date Input to Cost Estimate Complete _____Initial

8) ASSESSMENT OF SCHEDULE IMPACT AND LIST OF AFFECTED MILESTONES:

| Milestone | Level | ---Before CR--- Date | ---After CR--- Date | ---Delta (+/-)--- |
|---|---|---|---|---|

Run IIb Schedule Manager Concurrence _______ Initial / Date Input to Schedule Complete ________ Initial

9) SECONDARY IMPACT: ES&H AND OTHER COMMENTS:

10) APPROVALS

DØ Run IIb Project Manager ______________________________ Signature / Date

DØ Run IIb Level 2 Manager ______________________________ Signature / Date

DØ Run IIb Level 3 Manager ______________________________ Signature / Date

11) FERMILAB DIRECTOR DISPOSITION

O Approved O Disapproved ______________________________
Signature/Date

12) DOE DISPOSITION

O Approved O Disapproved ______________________________
Signature/Date

Figure 2. Sample Change Request form.

# 9 RISK MANAGEMENT ASSESSMENT

Detector upgrades are well within the experience and expertise of the DØ 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 Run IIb D-Zero Detector 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 Table 11.

Table 11. Risk impact factors for the Run IIb D-Zero Detector Project.

| **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 WBS level 4 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 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 between 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 Report, which includes detailed technical descriptions of the silicon detector, the trigger upgrade, the DAQ/Online upgrade, and installation and pre-beam commissioning.

## 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 cost account , thereby enabling comparison of obligations with the Cost Estimate at that level. Monthly tracking reports are produced that show all purchasing activity at the cost account level in each subproject.. 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 5. 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 through 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. This is performed by the WBS Level 2 and Level 3 Managers, and submitted to the Project Management for examination and review.

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 managers 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. Details regarding change control at DOE Levels 0 and 1 are contained in Section 6 of the PEP. 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 has been written that includes detailed technical descriptions of all Run IIb subsystems: silicon detector, trigger upgrade, DAQ/online upgrades, and installation and pre-beam commissioning. This report provides the basis for the technical baseline of the D-Zero Run IIb Detector Project.
Meetings and Reviews
Various meetings between the Directorate, Project Management, Subproject Managers and the Collaboration will be held at appropriate intervals to ensure management of the overall project.

10.7.2.1 DØ Project Management Group (PMG)

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

10.7.2.2 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.

10.7.2.3 General Upgrade Meetings

Eight general meetings will be held each year that will provide the opportunity for upgrade participants at every level to present status reports, discuss current issues and disseminate news and information. Whenever possible, these meetings will be synchronized with Collaboration meetings, held three to four times per year. 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.

10.7.2.4 Subproject Meetings

Meetings shall be called by Subproject Managers, typically at a bi-weekly interval, 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 DØ 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 satisfaction of technical specifications. The subproject manager is responsible for devising appropriate inspections. Acceptance of components and systems will be done by those individuals 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 interactions and potential conflicts between distinct detector, trigger and readout systems are confronted 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 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 Run IIb D-Zero Detector 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 Project is the responsibility of the Project Manager. The 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 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 and the Subproject Managers are the laboratory line management on matters of environment, safety, and health for the Project. The Project Manager is also responsible for ensuring that adequate safety documentation is provided for installation and operation of the upgraded detector. The resources of the Particle Physics Division ES&H Department are available to the Project Manager and Subproject Managers 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.