Project Execution Plan

for the

12 GeV CEBAF Upgrade

at

Jefferson Lab

For the U.S. Department of Energy
Office of Science
Office of Nuclear Physics (SC – 26)

August 2013

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Office of Nuclear Physics
Exploring Nuclear Matter - Quarks to Stars

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CHANGE LOG

Revision No.	Pages Affected	Effective Date
1	Minor text edits as needed to reflect updated information: Figures 4.1, 5.1, 5.2; Tables 5.2, 5.3, 5.4, 5.5, 7.1; and Appendix B.	July 2008
2	Pages Affected: Figure 5.1 and Table7.1	October 2008
3	Minor text edits as needed to reflect updated information. Revised Section 5.2 with new Table 5.7. Updated Figures 4.1, 4.2, 5.1, and 5.2. Updated Tables 5.3, 5.4, and 7.1.	September 2009
4	Minor text edits as needed to reflect updated information. Updated Figures 4.1, 4.2, 5.1, and 5.2. Updated Tables 5.2, 5.3, 5.4, 5.6, 5.7 and 7.1.	September 2010
5	Minor text edits as needed to reflect updated information. Updated Figures 4.1, 4.2, 5.1 and 5.2. Updated Tables 5.2, 5.3, 5.4 and 5.6.	October 2011
6	Updated text as needed to reflect proposed rebaseline plan. Updated Figures 4.1, 5.1 and 5.2. Updated Tables 5.1B, 5.2. Deleted Table 5.3. Updated Tables 5.4 and 5.6. Updated Appendix B.	November 2012
7	Updated text as needed to reflect proposed rebaseline plan. Updated Figures 4.1, 5.1 and 5.2. Updated Tables 5.1B, 5.2. Updated Tables 5.4 and 5.6. Restored Table 5.3. Updated Appendix B.	April 2013
8	Updated Signature page, Table 5.1B, Table 5.3, Table 5.5, Table 5.6, Table 6.1, Figure 5.1 and Figure 5.2.	August 2013

1.0 Introduction

Thomas Jefferson National Accelerator Facility (Jefferson Lab), located in Newport News, VA, is owned by the U.S. Department of Energy (DOE) and operated by Jefferson Science Associates, LLC (JSA) under the Department of Energy Contract No. DE-AC05-06OR23177. JSA is a Southeastern Universities Research Association/Computer Sciences Corporation limited liability company created specifically to manage and operate Jefferson Lab. The DOE Office of Nuclear Physics (NP) within the Office of Science (SC) operates the Continuous Electron Beam Accelerator Facility (CEBAF) as a National User Facility at Jefferson Lab.

The Director of the Office of Science (SC), Raymond L. Orbach, approved the Critical Decision-Zero (CD-0) of the 12 GeV CEBAF Upgrade project on March 31, 2004 and CD-1 on February 14, 2006. The preliminary Total Project Cost (TPC) was estimated at CD-0 to be $170,000,000 - $250,000,000 and at CD-1 the TPC range was adjusted to $225,000,000 - $300,000,000. However, the preliminary total project cost range was updated in the FY2008 Congressional Budget to between $225,000,000 and $306,000,000 due to slippage in the planned funding profile. In June 2007, the Office of Science carried out an Independent Project Review to assess readiness for an External Independent Review (EIR) and approval of CD-2, Approve Performance Baseline. As a result of this review, the upper limit to the preliminary cost range was refined to $310,000,000. A resource loaded schedule, including a critical path was established. An EIR was held by the DOE Office of Acquisition & Project Management (OAPM, formerly the Office of Engineering and Construction Management) in September 2007 and CD-2 Approval was awarded in November 2007 thus determining the project baseline for cost, schedule, and scope. Conceptual design was supported in Fiscal Year (FY) 2004 and FY 2005, and Research and Development (R&D) in FY 2004 through FY 2008. Project Engineering and Design (PED) funds were initiated in FY 2006 and continued through FY 2009. CD-3, Approve Start of Construction, was approved in September 2008. Construction started in FY 2009 with a planned CD-4B in FY 2015 based on an anticipated funding profile. However, Congressional action reduced the FY 2012 funding from $66,000,000 to $50,000,000. As a result of this directed change and challenges associated with the procurement of seven superconducting magnets in Halls B and C, the TPC has increased to $338,000,000 with a CD-4B completion scheduled September 2017.

This Project Execution Plan (PEP) describes the coordination of efforts of the 12 GeV Integrated Project Team (IPT), Executive Leadership and IPT Subject Matter Experts (SMEs), including the processes and procedures which will be used to ensure that the project will be completed on time and within budget. The PEP also includes key elements of the project plan including, but not limited to, the following: defines the project scope, describes the organizational framework and management systems, identifies roles and responsibilities of contributors, presents the Work Breakdown Structure (WBS) and high-level cost and schedule, and describes the formal change control processes by which project cost, schedule, or scope may be revised.

2.0 Mission Need

The mission of the NP program is to foster fundamental research in nuclear physics that will provide new insights and advance our knowledge on the nature of matter and energy and develop the scientific knowledge, technologies and trained manpower that are needed to underpin the DOE missions for nuclear related national security, energy and environmental quality. As part of its strategic mission, the NP program plans, constructs and operates major scientific user facilities and fabricates experimental equipment to serve researchers at universities, national laboratories and industrial laboratories. The program provides world-class, peer-reviewed research results in the scientific disciplines encompassed by the NP mission areas under the mandate provided in Public Law 95-91 that established the Department.

The CEBAF at Jefferson Lab is the world-leading facility in the experimental study of hadronic matter. The 12 GeV CEBAF Upgrade directly addresses a major scientific opportunity identified in both the 2002 and the 2007 Long Range Plans in which the Nuclear Science Advisory Committee (NSAC) recommends the 12 GeV CEBAF Upgrade as one of its highest priorities for the Nuclear Physics program. The project was identified as a high priority initiative in the Office of Science's plan, "Facilities for the Future of Science: A Twenty Year Plan".

The 12 GeV CEBAF Upgrade directly supports the Nuclear Physics mission and addresses the objective to measure properties of the proton, neutron, and simple nuclei for comparison with theoretical calculations to provide an improved quantitative understanding of their quark substructure.

The 12 GeV CEBAF Upgrade will enable CEBAF's world-wide user community to expand its research horizons, and will allow breakthrough programs to be launched in three key areas:

- The experimental verification of the powerful force fields ("flux tubes") believed to be responsible for quark confinement; understanding confinement is essential for understanding the structure of nuclear matter;
- The measurement of the quark and gluon structure of the proton, the neutron, and other nuclear building blocks at the most basic quantum level; and
- New research domains in key areas already under investigation.

3.0 Project Description

3.1 Overview

The full scope of the 12 GeV CEBAF Upgrade project includes upgrading the electron energy of the main accelerator from 6 GeV (billion electron volts) to 12 GeV, constructing a new experimental area (Hall D), and enhancing the capabilities in the existing experimental halls to support the most compelling nuclear physics research. All efforts include design, construction, installation, and testing and commissioning.

CEBAF is comprised of an inter-connected pair of anti-parallel linacs, each with twenty cryomodules, with each cryomodule in turn containing eight superconducting radio-frequency (SRF) accelerating five-cell cavities. The 12 GeV CEBAF Upgrade project can be attained cost-effectively by using the space already available in the linac tunnels to install ten new cryomodules fabricated with higher-performing seven-cell cavities. A diagram showing the major components of the project can be seen in Figure 3.1. Additional technical information on the project design can be found in the accelerator and experimental equipment Design Solution Documents as well as the Space Program documents for the civil construction.

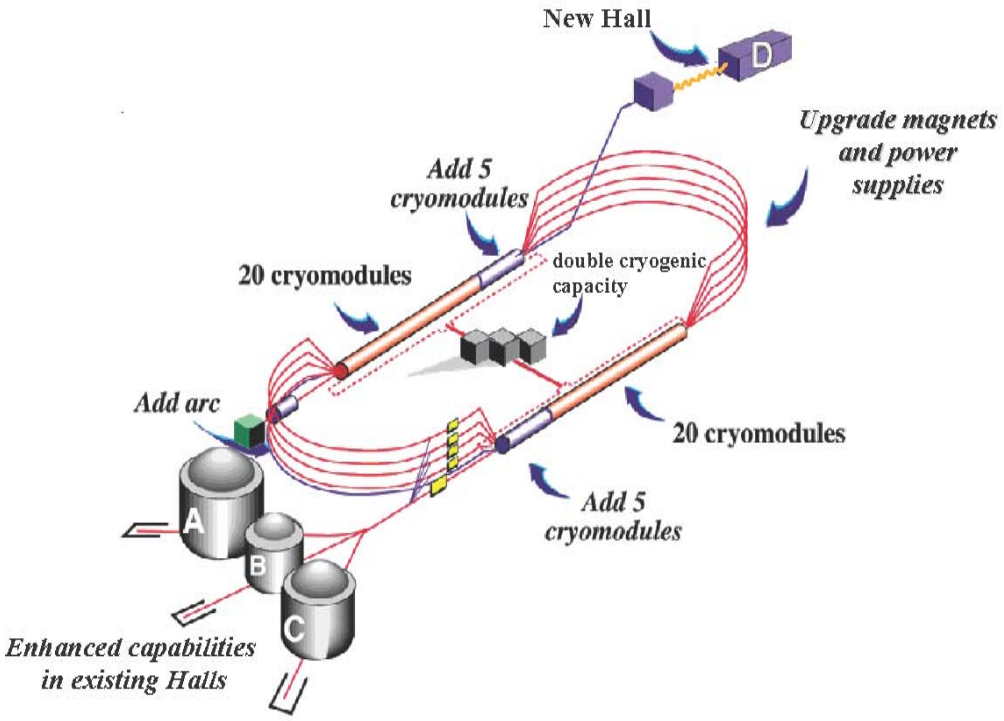


Figure 3.1. Main components of 12 GeV CEBAF Upgrade.

3.2 Accelerator

The accelerator portion of the upgrade will be constructed on the framework of the existing CEBAF accelerator. A new tenth arc will allow an additional "half-pass" through the accelerator thus achieving the capability to reach the 12 GeV beam energy followed by beam transport to a newly constructed Hall D tagger area. Beam at energies up to 11 GeV will be possible to Halls A, B, and C. The beam transport system allows for operation of up to 3 halls simultaneously if desired, with no two halls receiving the same beam energy.

3.3 Halls A, B, & C Experimental Equipment

The increased physics capabilities of the existing halls comes from the qualitative jump in energy and momentum transfer that the machine upgrade brings, and from the enhanced instrumentation capabilities planned for the detector complements in each of them. In general terms, the phrase "12 GeV" has been used to describe the overall Upgrade. The physics capabilities in Halls A, B, and C are based on an electron beam with a maximum energy of 11 GeV.

Enhancements to the three existing halls include the following:

Hall A – The beamline will be upgraded to achieve the capability of delivering the maximum energy 5-pass beam to the existing Hall spectrometers. This Hall will be used for special set-up experiments, and have continued use for experiments where energy resolution sufficient to separate nuclear levels is important.

Hall B – The CEBAF Large Acceptance Spectrometer (CLAS) will be upgraded to CLAS12 with new magnets and detectors to study exclusive reactions at high energy. Facility enhancements will result in a significant increase over current CLAS operating conditions including detection capabilities that are not currently present.

Hall C - A new focusing spectrometer system (SHMS) will enable precision cross section measurements with particles scattered at up to full beam momentum. This will be used together with the existing High Momentum Spectrometer (HMS). Hall C's magnetic spectrometer pair will be rigidly connected to a central pivot to permit rapid, remote angle changes and reproducible rotation characteristics, to simplify accurate measurement.

3.4 Hall D Experimental Equipment

Using the 12 GeV electron beam in the new Hall D, a tagged coherent bremsstrahlung (photon) beam and a new hermetic detector (with an existing superconducting solenoid magnet) will be used to carry out a program of exotic meson spectroscopy aimed at experimentally testing the understanding of quark confinement.

3.5 Civil Construction

The major conventional construction will be the new experimental Hall D complex including the accelerator tunnel extension. The remaining conventional construction is modifications to support facilities which are primarily associated with utility upgrades. There will be an addition to the Central Helium Liquefier (CHL) building to accommodate the additional refrigeration equipment. The low conductivity water (LCW) and electrical distribution systems will be upgraded to support the accelerator operations at 12 GeV.

4.0 Management Organization, Roles and Responsibilities

SC is the DOE program office responsible for the 12 GeV CEBAF Upgrade project and SC's Office of Nuclear Physics provides funding for the project directly via approved financial plans. As Management and Operating (M&O) contractor for Jefferson Lab, JSA is responsible to DOE for carrying out the 12 GeV CEBAF Upgrade project. JSA has delegated to Jefferson Lab the responsibility for research and development, design, construction, and operation of the 12 GeV CEBAF Upgrade. The roles and responsibilities of the project participants are summarized in the following subsections. The 12 GeV CEBAF Upgrade Project Organizational Chart is shown in Figure 4.2.

The 12 GeV CEBAF Upgrade is being constructed on the Jefferson Lab site. The project team coordinates construction activities with ongoing CEBAF operation, as well as other potential projects and efforts such as operation of the Free Electron Laser (FEL), also located on the Jefferson Lab site.

4.1 Integrated Project Team (IPT)

DOE and Jefferson Lab are using an Integrated Project Team approach for the management of the 12 GeV CEBAF Upgrade Project. The IPT, comprised of both DOE and Jefferson Lab members, is led by the 12 GeV Federal Project Director (FPD). The membership is expected to evolve and change as the 12 GeV CEBAF Upgrade project progresses from initiation to close-out to ensure that all project needs are being met. In addition to the core IPT, there is also the Executive Leadership and the IPT Subject Matter Experts (SMEs).

The charter of the 12 GeV IPT is to provide effective leadership and guidance to the 12 GeV CEBAF Upgrade project, which will be accomplished through teamwork; clear identification of roles, responsibilities and authorities; accurate and timely reporting; open communications; and professional accountability of the IPT, IPT SMEs and the 12 GeV Project Team.

The Executive Leadership provides broad leadership and guidance to the IPT, and ensures that adequate resources and the necessary tools from their respective organizations are provided to the IPT and 12 GeV Project Team. Figure 4.1 lists the IPT Executive Leadership, and their responsibilities are delineated in Sections 4.2 and 4.3. Federal leadership and guidance will be communicated through the NP 12 GeV Program Manager and 12 GeV FPD. Contractor leadership and guidance will be communicated through the Jefferson Lab 12 GeV Project Manager.

The 12 GeV IPT SMEs consist of both Federal and Jefferson Lab staff who provide support to the IPT on an as-needed basis. The SMEs include both Federal and contractor contracting, ES&H, engineering, and scientific expertise. Because of the dynamic nature of the project, the skill mix will change throughout the life of the project.

The core IPT meets periodically to address Project leadership actions and issues. The meetings focus on near-term priorities and actions associated with the project. On an as-needed basis, Executive Leadership and/or SMEs are requested to participate in IPT meetings or are assigned actions that require their expertise. The standing agenda for the IPT meetings includes topics such as; ES&H, anticipated baseline change control activity, changes in risk assessments, report preparation, milestone changes, and emerging issues. The IPT also meets monthly to discuss the status of the project. These meetings are usually attended by members of the Executive Leadership and SMEs. A monthly project status report is generated by the 12 GeV Project Team and provided to the IPT.

4.2 Department of Energy (DOE)

4.2.1 Office of Science

The Office of Science, Deputy Director for Science Programs (SC-2) serves as the Acquisition Executive (AE) for this project. As such, SC-2 has full responsibility for project planning and execution, and for establishing broad policies and requirements for achieving project goals. Specific responsibilities for this project include:

- Chairs the ESAAB Equivalent Board,
- Approves Critical Decisions (except CD-4A decision which is delegated to the Associate Director for the Office of Nuclear Physics) and Level 0 baseline changes,
- Approves the Project Execution Plan, and
- Delegates approval authority baseline changes.

4.2.2 Office of Nuclear Physics

The Associate Director for the Office of Nuclear Physics (SC-26) manages the program organization responsible for planning, constructing, and operating user facilities. These facilities provide special scientific and research capabilities to serve the needs of U.S. universities, industry, and private and Federal laboratories in the nuclear physics field. The Associate Director, with assistance from the Division Director for Facilities and Project Management within SC-26, has specific responsibilities for this project that include:

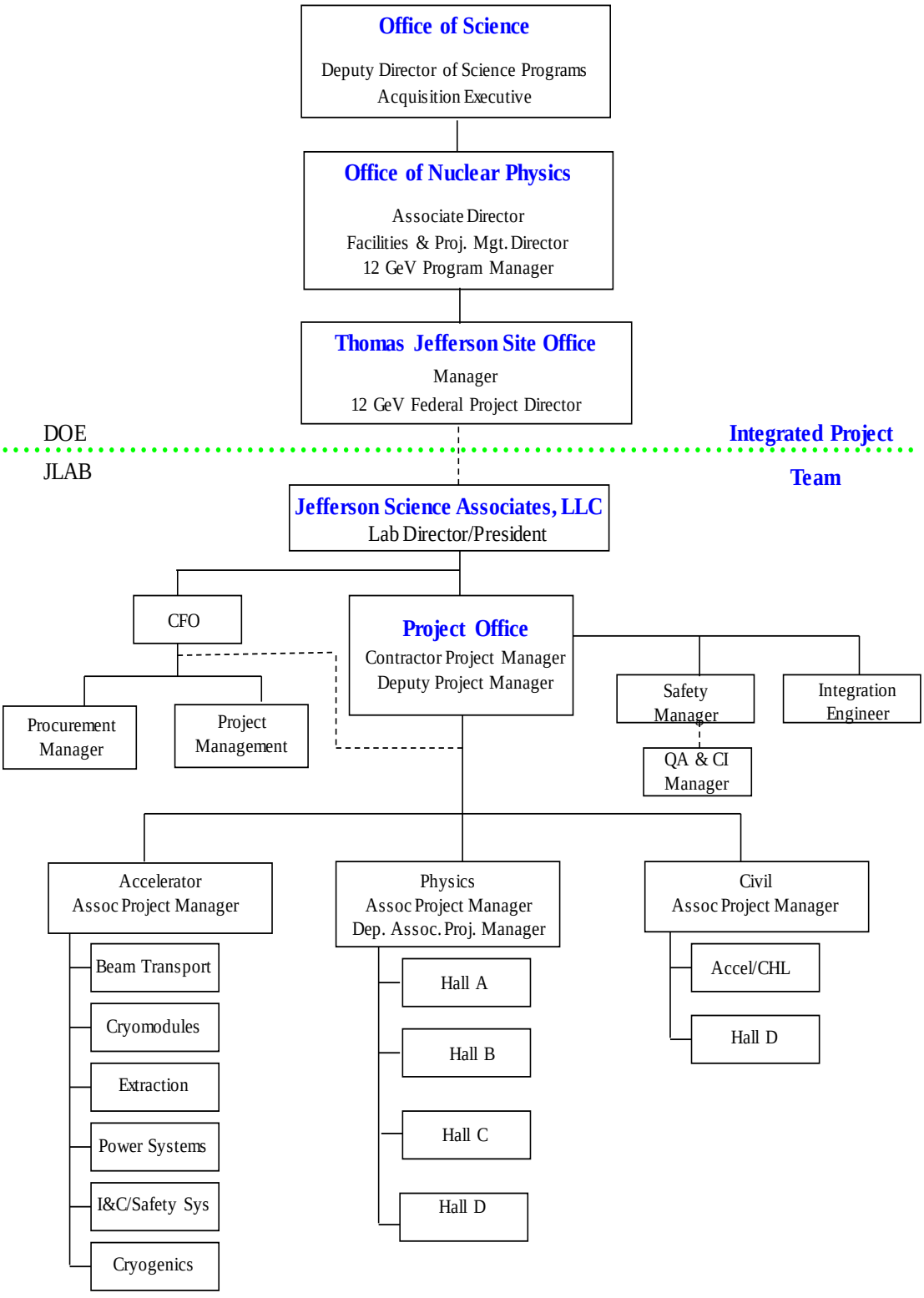
- Approves Level 1 baseline changes,
- Reviews and provides recommendations to Level 0 baseline changes,
- Approves CD-4A critical decisions,
- Provides executive leadership to the 12 GeV IPT, and
- Provides funding for the construction and operation of the facility.

Figure 4.1
12 GeV Integrated Project Team, Executive Leadership & SMEs

NAME	POSITION	ORGANIZATION
12 GeV INTEGRATED PROJECT TEAM (IPT)		
M. Epps	12 GeV Federal Project Director	DOE-TJSO
J. Hawkins	NP 12 GeV Program Manager	DOE-NP
C. H. Rode	JLab Contractor Project Manager	JSA-TJNAF
A. Lung	JLab Deputy Contractor Project Manager	JSA-TJNAF
12 GeV EXECUTIVE LEADERSHIP		
T. Hallman	Associate Director, SC NP	DOE-NP
J. Gillo	Director, Facilities and Project Management Division, SC NP	DOE-NP
J. Arango	Site Office Manager	DOE-TJSO
H. Montgomery	JLab Director / JSA President	JSA-TJNAF
12 GeV IPT SUBJECT MATTER EXPERTS (SMEs)		
T. Barnes (Acting)	NP Medium Energy Physics Program Manager	DOE-NP
M. Farkhondeh	NP Advanced Technology Research and Development Program Manager	DOE-NP
J. Skinner	Federal Contracting Officer	DOE-TJSO
ES&H Team	E,S&H/ISMS	DOE-TJSO
L. Harwood	JLab Assoc. PM: Accelerator	JSA-TJNAF
G. Young	JLab Assoc. PM: Physics	JSA-TJNAF
R. Yasky	JLab Assoc. PM: Civil	JSA-TJNAF
P. Collins	JLab Safety Manager	JSA-TJNAF
L. McKnight	JLab Procurements & Contracts	JSA-TJNAF
D. Napier	JLab Integration Engineer	JSA-TJNAF

Yellow background indicates a member from DOE-NP
Blue background indicates a member from the Thomas Jefferson Site Office (TJSO)
Gray background indicates a member from Jefferson Lab (also known as JLab or TJNAF)

Figure 4.2
12GeV CEBAF Upgrade Project Organizational Chart



The NP 12 GeV Program Manager serves as the primary point of contact within SC-26 with the following responsibilities:

- Participates as a member of the 12 GeV IPT,
- Oversees and provides guidance on the development of project documentation,
- Provides programmatic direction via the Federal Project Director,
- Functions as DOE SC and NP headquarters point of contact,
- Oversees progress and helps to organize reviews as necessary,
- Develops and justifies budgets to execute project,
- Reviews and provides recommendations to senior management on Level 0 and Level 1 baseline changes,
- Monitors Level 2 baseline changes, and
- Monitors Level 1 and 2 technical, cost, and schedule milestones.

4.2.3 Thomas Jefferson Site Office (TJSO)

The TJSO Manager provides executive leadership to the 12 GeV IPT. He is also responsible for ensuring the necessary and effective TJSO resources and support are provided to the project.

The Federal Project Director at the Thomas Jefferson Site Office (TJSO) shall be the single point of contact between Federal and Jefferson Lab staff for all matters relating to the 12 GeV CEBAF Upgrade project and its performance. The FPD is officially responsible and accountable for the overall success of the 12 GeV CEBAF Upgrade project. Specific responsibilities include:

- Provides effective leadership to the 12 GeV IPT,
- Ensures timely completion and quality of required project documentation and other deliverables,
- Provides overall project management oversight, assesses contractor project performance versus plan and requirements, and reports project performance to DOE management,
- Approves or reviews and recommends approval of baseline changes in accordance with the approved baseline change control process,
- Serves as the 12 GeV DOE Contract Technical Monitor,
- Coordinates Level 0 and 1 baseline changes with the NP 12 GeV Program Manager,
- Maintains project data in the DOE Project Assessment and Reporting System (PARS II),
- Monitors contractor’s risk management efforts, and
- Ensures that project complies with applicable Environment, Safety and Health (ES&H) requirements.

4.3 Thomas Jefferson National Accelerator Facility

Jefferson Lab will manage the project and procure the special technical equipment and Architect/Engineering services as needed. Jefferson Lab will also provide construction management services and procurement of construction services (e.g., FPSC). Jefferson Lab also has lead responsibility for managing all non-DOE funding sources/collaborators associated with the 12 GeV CEBAF Upgrade project within the established project framework.

4.3.1 Laboratory Director

The Laboratory Director has been provided by JSA with the overall responsibility for all projects, programs, operations, and facilities at Jefferson Lab. The Laboratory Director has the responsibility for completing the 12 GeV CEBAF Upgrade project within the technical, schedule, and cost baselines defined in the PEP. The Laboratory Director appoints the 12 Upgrade Project Manager and assigns him/her full decision making authority for the Upgrade project. The Laboratory Director also provides executive leadership to the 12 GeV IPT.

4.3.2 Project Office

4.3.2.1 Jefferson Lab 12 GeV Project Manager

The Jefferson Lab 12 GeV Project Manager (also known as the Contractor Project Manager or CPM) provides project management for the design, construction and commissioning of the 12 GeV CEBAF Upgrade. The 12 GeV Project Manager reports to the Laboratory Director. Specific duties and responsibilities include:

- Lead responsibility within the Laboratory for developing project goals and priorities and delivering the scientific and technical performance of the 12 GeV CEBAF Upgrade within cost and schedule requirements,
- Ensures that effective project management systems, cost controls and milestone schedules are developed, documented and implemented to assess project performance and achieve project deliverables,
- Directs the Deputy Project Manager and Associate Project Managers in the day to day management of the 12 GeV CEBAF Upgrade and in the development and utilization of project planning, execution and assessment tools,
- In collaboration with the Laboratory Director, Chief Operating Officer, and Associate Directors for Experimental Nuclear Physics and Accelerator Operations meets with the project advisory committees and user community to align project performance and scientific objectives,
- Ensures that DOE requirements are adhered to including project documentation and reporting, performance risk assessments, and EH&S,
- Manages the Jefferson Lab 12 GeV Project Team,
- Ensures that ES&H responsibilities and requirements are integrated into the project,
- Chairs the Change Control Board,

- Primary responsibility for management of non-DOE scope contributions, and
- Primary Jefferson Lab point of contact with the 12 GeV Federal Project Director.

4.3.2.2 Deputy Project Manager

- Secondary responsibility within the Laboratory for developing project goals and priorities and delivering the scientific and technical performance of the 12 GeV CEBAF Upgrade within cost and schedule requirements,
- Primary responsibility for incorporation of non-DOE scope contributions into framework of managed project,
- Primary responsibility for project-wide reviews and logistics,
- Oversees the development of all laboratory project documents and brochures created for DOE, the larger scientific community, and the general public, and
- Secondary Jefferson Lab point of contact to the 12 GeV Federal Project Director.

4.3.2.4 Accelerator Associate Project Manager

He/she provides project management for the design, construction, checkout and beam commissioning of the Accelerator Systems.

4.3.2.5 Physics Associate Project Manager

He/she provides project management for the design, construction, checkout and beam commissioning of the Physics Experimental Systems.

4.3.2.6 Deputy Physics Associate Project Manager

He/she provides the Physics Associate Project Manager with support for the construction, checkout and beam commissioning of the experimental detector systems.

4.3.2.7 Civil Associate Project Manager

He/she provides project management for the design, construction and checkout of the conventional facilities for the project.

4.3.2.8 Assistant Project Managers

Also known as Control Account Managers or CAMs, the Assistant Project Managers provide the project management for the design, construction, checkout, and beam commissioning of their respective WBS subsystems within the three primary project components (Accelerator, Physics, and Civil). They are experienced Jefferson Lab employees who are principally matrixed to the 12 GeV CEBAF Upgrade project from within home divisions.

4.3.3 Support Staff

4.3.3.1 Safety Manager
He/she is responsible for the implementation of all Jefferson Lab safety management standards throughout the planning and execution of the project. He/she provides coordination of all resources from the ESH&Q Division in support of the 12 GeV CEBAF Upgrade.

4.3.3.2 Quality Assurance (QA)
The Manager of the Quality Assurance and Continuous Improvement office reports to the Associate Director for ESH&Q and provides staff support to the 12 GeV CEBAF Upgrade for efforts including evaluation of vendor contract bids, assessment of vendor QA plans, and development of the 12 GeV Supplemental Quality Assurance Plan. This support is coordinated through the 12 GeV Safety Manager.

4.3.3.3 Integration Engineer
He/she provides oversight for the installation and commissioning plans, and generates/maintains interface control documentation.

4.3.4 Key Jefferson Lab Interfaces

4.3.4.1 Jefferson Lab Associate Directors (AD)
The Laboratory's Associate Director for Accelerator Operations and Associate Director for Experimental Nuclear Physics are members of the Lab Leadership Group, and as such participate in high level project planning discussions and decisions. They are also suppliers of critical matrix effort to the project.

4.3.4.2 Jefferson Lab Department Managers
The Engineering Group Manager and the Facilities and Logistics Group Manager participate in weekly priorities meetings and are the suppliers of critical matrix effort to the project.

4.3.4.3 Project Management and Integrated Planning (PMIP)
The Manager of the Project Management and Integrated Planning Office reports to the Lab Chief Financial Officer and provides staff support to the 12 GeV CEBAF Upgrade for efforts including costbook maintenance, resource loaded schedule maintenance, earned value tracking, and change control tracking.

4.3.4.4 Procurement Manager
The Manager of the Procurement Office reports to the Lab Chief Financial Officer and provides staff support to the 12 GeV CEBAF Upgrade for efforts including Advance Procurement Plans for major procurements, contract bid evaluation and award, contract/vendor oversight, and SOTR training.

5.0 Project Baselines

The project has been organized into a Work Breakdown Structure (WBS) for purposes of planning, managing and reporting project activities. The WBS is developed through Level 5 or below as appropriate for all major subsystems. Work elements are defined consistent with discrete increments of project work and the planned method of accomplishment. The high level WBS dictionary is included in this document as Appendix B. Formal baselines for the 12 GeV CEBAF Upgrade defined at CD-2 can only be modified by approved Baseline Change Proposals (refer to Section 6.0).

5.1 Technical Scope and Deliverables

The project comprises completion of the subsystems, including pre- and post-installation acceptance testing, as defined by the project Critical Decision-Four (CD-4A and CD-4B) deliverables (see Table 5.1A and 5.1B). A phased approach to CD-4 is being used to reflect the earlier completion of the accelerator and conventional facilities installation and commissioning, separately from the experimental equipment.

Table 5.1A
CD-4A, Deliverables / Key Parameters

Subsystem	Technical Definition of Completion	Completion Date
Accelerator	12 GeV capable 5.5 pass machine installed	December 2014
Accelerator	11 GeV capable beamline to Halls A, B, and C installed	December 2014
Accelerator	12 GeV capable beamline to Hall D tagger area installed	December 2014
Accelerator	Accelerator commissioned by transporting a $\geq$ 2 nA electron beam at 2.2 GeV (1 pass)	December 2014
Conventional Facilities	New Experimental Hall and the Counting House: $\geq$ 10,500 square feet	December 2014

Table 5.1B
CD-4B, Deliverables / Key Parameters

Subsystem	Technical Definition of Completion	Completion Date
Hall B	Detector operational: events recorded with a $\geq$ 2 nA electron beam at > 6 GeV beam energy (3 pass)	September 2017
Hall C	Detector operational: events recorded with a $\geq$ 2 nA electron beam at > 6 GeV beam energy (3 pass)	September 2017
Hall D	Detector operational: events recorded with a $\geq$ 2 nA electron beam at > 10 GeV beam energy (5.5 pass)	September 2017

5.2 Cost

The rebaselined Total Project Cost is $338 million, the Total Estimated Cost (TEC) is $310.5 million and Other Project Costs (OPC) is $27.5 million. Jefferson Lab will aggressively and actively seek non-DOE funding sources such as international collaborations and the National Science Foundation for some of the experimental equipment, as well as from the Commonwealth of Virginia through a Work for Others contract. This is consistent with experience during the construction of CEBAF and its subsequent operation including new large installation experimental equipment. The precise timeframe for commitments by non-DOE contributors will vary throughout the life of the project and become more certain as the project progresses. Though non-DOE funding sources are anticipated, DOE's originally planned funding profile supported the entire planned scope of the 12 GeV CEBAF Upgrade project. Since then, some scope was addressed under the Commonwealth of Virginia Work for Others contract. This effort has been accounted for in the rebaseline TPC. All non-DOE funding sources will continue be communicated to the Office of Nuclear Physics through the NP 12 GeV Program Manager and incorporated into the project through the change control process.

Escalation on the DOE TPC is calculated on a year-by-year basis. Project costs in FY 2013 dollars are escalated by applying a multiplicative factor to costs scheduled to accrue in a given fiscal year. The outyear escalation rate of 3.19% was estimated using historical data on labor rates, civil construction, capital equipment, and OMB trends. The rates applied for the outyear project plan are shown in Table 5.2.

Table 5.2
Escalation Rates Relative to FY13$ Per Fiscal Year

Fiscal Year	Yearly	Accumulative
FY13	1.0000	1.0000
FY14	1.0319	1.0319
FY15	1.0319	1.0650
FY16	1.0319	1.0990

The project costs relative to Work Breakdown Structure (WBS) at Level 2 are shown in Table 5.3, where ETC is the Estimate-To-Complete. This represents a $28M increase to the TPC approved at CD-2 in November 2007. An updated project cost summary, including the information shown in Table 5.3, is included in the 12 GeV CEBAF Upgrade Monthly Reports.

Table 5.3.Total Project Cost Summary by WBS Level 2.

	12 GeV Cost Summary	
		EAC (AY M$)
WBS	**SCOPE**	**COST**
1.2.	PED	21.0
1.3.	Accelerator systems	103.7
1.4.	Upgrade Hall A, B & C	90.0
1.5.	Hall D	40.0
1.6.	Civil	30.4
1.7.	Project Management	9.2
TEC Subtotal		**294.3**
31-Jul-2013 Costs with 31-Aug-2013 Estimates		(243.4)
TEC ETC		50.9
TEC Contingency		**15.2**
% of ETC		30%
TEC Management Reserve		**1.0**
% of ETC		2%
TEC TOTAL (AY M$)		**310.5**
1.0	CDR/ACD	3.4
1.1.	R&D	7.1
1.8.	Pre-Ops	12.1
OPC SUBTOTAL		**22.6**
31-Jul-2013 Costs with 31-Aug-2013 Estimates		(12.4)
OPC ETC		10.2
OPC Contingency		**4.4**
% of ETC		43%
OPC Management Reserve		**0.5**
% of ETC		5%
OPC TOTAL (AY M$)		**27.5**
TPC TOTAL (AY M$)		**338.0**

The current funding profile for the project is shown in Table 5.4. Funds in FY 2004 through FY 2006 were for R&D and the development of a Conceptual Design Report. R&D funding continued through FY 2008. The design phase was funded with PED funds. PED funding started in late FY 2006 and continued through FY 2009. Construction funding started in FY 2009 and will continue through FY 2016. No construction funds were used until the Performance Baseline was validated and CD-3 was

approved. Testing and commissioning activities known as the Pre-Ops phase will be supported in FY 2013 through FY 2017.

Table 5.4.
August 2013 Re-baseline Funding Profile ($K)

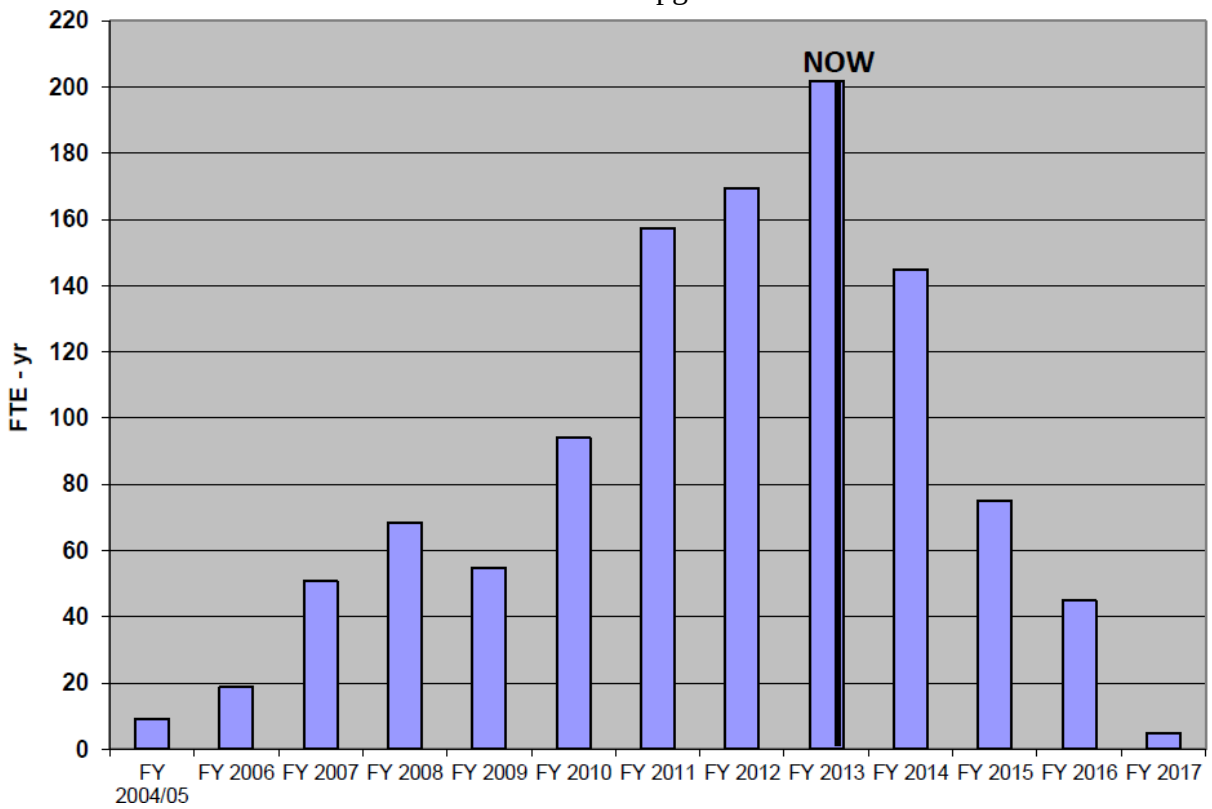
Fiscal Year	R&D/ CDR	PED	Constr.	PreOps	TEC	OPC	TPC
FY 2004	700					700	700
FY 2005	2,300					2,300	2,300
FY 2006	4,000	500			500	4,000	4,500
FY 2007	2,500	7,000			7,000	2,500	9,500
FY 2008	1,000	13,377			13,377	1,000	14,377
FY 2009		123	28,500		28,623		28,623
FY 2009 (ARRA)			65,000		65,000		65,000
FY 2010			20,000		20,000		20,000
FY 2011			35,928		35,928		35,928
FY 2012			50,000		50,000		50,000
FY 2013			40,572	2,500	40,572	2,500	43,072
FY2014			25,500	4,500	25,500	4,500	30,000
FY2015			16,500	4,500	16,500	4,500	21,000
FY2016			7,500	4,500	7,500	4,500	12,000
FY2017				1,000		1,000	1,000
TOTAL	10,500	21,000	289,500	17,000	310,500	27,500	338,000

The funding profile on which the baseline project plan was developed was adjusted in FY 2009. Through the American Recovery and Reinvestment Act (ARRA), $65,000,000 in line item construction funding was received in April 2009 to advance the funding profile of the Project, thereby reducing the cost risk and schedule risk. Specifically, this funding was provided to optimize project execution by advancing the schedule for some civil construction and accelerator component subcontracts as compared to its already approved project baseline plan. Subsequently, adjustments were made to reduce the FY 2010 and FY 2011 funding for the project thus maintaining the TEC and TPC of the baseline plan at that time.

The funding profile was adjusted again in response to the directed change of a $16,000,000 reduction in the FY 2012 allocation, and the subsequent rebaseline of the project. Table 5.4 shows the re-baseline funding profile in support of the rebaseline effort.

Figure 5.1 shows the estimated Jefferson Lab workforce needs for the 12 GeV Upgrade as a function of fiscal year. The workforce includes expected out year contingency expenditures and purchased contract labor. It peaks at ~200 FTEs in 2013 during the machine shutdown and hardware installation period. For reference, the total staff at Jefferson Lab is approximately 700 employees.

Figure 5.1
Jefferson Lab 12 GeV Upgrade Workforce



5.3 Schedule

To address possible impacts from a Continuing Resolution (CR), the obligation profile for construction funding is based on the assumption that funds will be available at a minimum of one-twelfth of the previous budget year allocation for the first fiscal quarter. Figure 5.2 provides the Project summary level schedule, including Level 1 Critical Decision milestones. The schedule is based on the funding guidance for the rebaseline, and is supported by the profile shown in Table 5.4. The schedule contingency to CD-4B at the time of the 2013 baseline change request is 18 months (58%).

A list of high level schedule milestones has been established in order to track progress on key elements and activities. Significant changes to the CD-4 milestone are under the control of the AE (Level 0). Significant changes to the other Critical Decision schedule milestones are under the control of the SC Associate Director. The Level 2 schedule milestones correspond to the completion of significant scopes of work and are managed by the Federal Project Director. The Critical Decision milestones are shown in Table 5.5. Phased CD-4 approvals are planned to phase in accelerator project completion and experimental equipment project completion with the final CD-4B scheduled for June 2015 (see Table 5.1A and 5.1B). The Level 2 schedule milestones are shown in Table 5.6. Additional milestones have been included as part of the project rebaseline plan. The Level 3 milestones will be monitored jointly by the Federal Project Director and the Jefferson Lab 12 GeV Project Manager.

Figure 5.2
High Level Schedule Based on Re-baseline Funding Profile

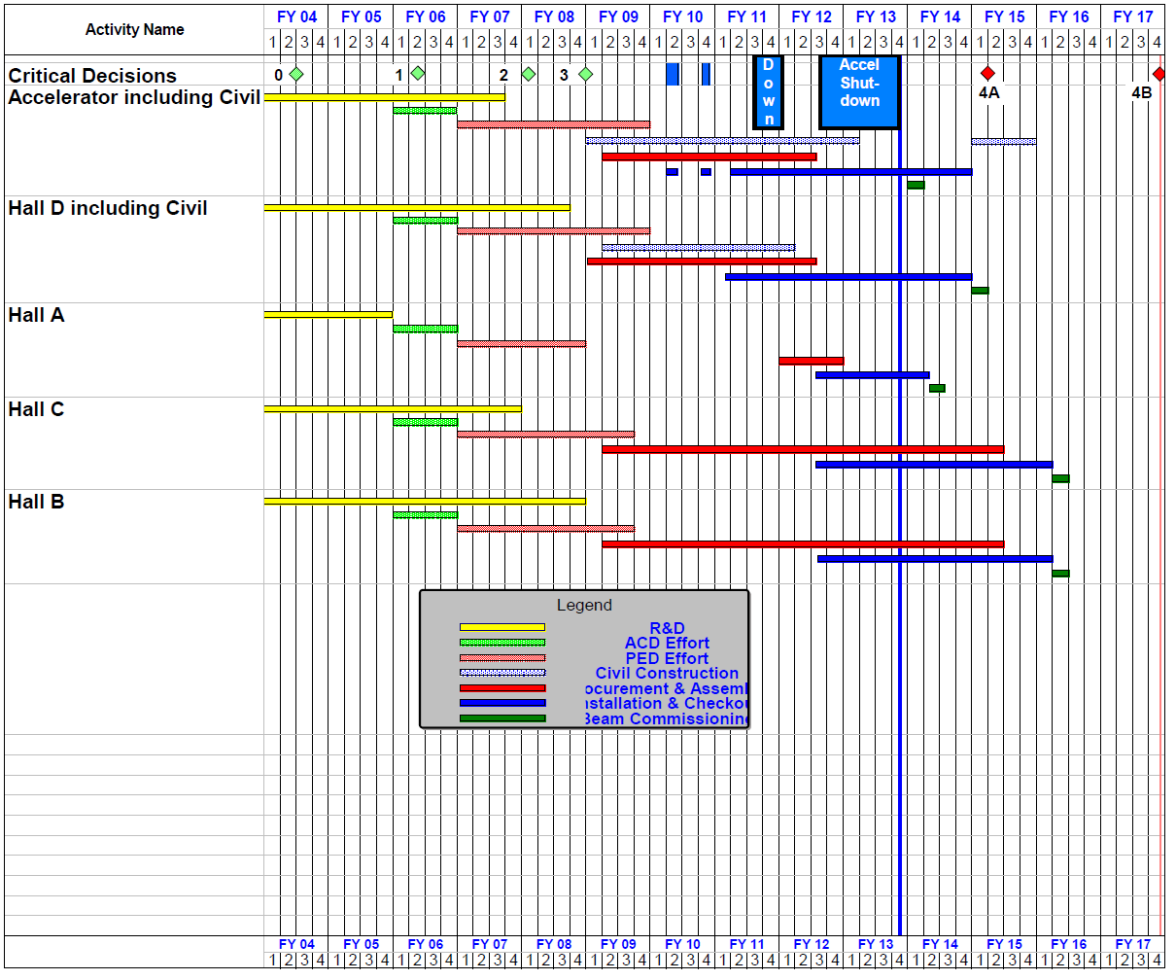


Table 5.5
Project Management and Control Milestones Level 1: Critical Decision Schedule
("(A)" indicates actual completion date)

Level and Number	Milestone Description	Completion Date
	Level 1	
1-1	CD-0 (Approve Mission Need)	Mar-2004 (A)
1-2	CD-1 (Approve Preliminary Baseline Range)	Feb-2006 (A)
1-3	CD-2 (Approve Performance Baseline)	Nov-2007 (A)
1-4	CD-3 (Approve Start of Construction)	Sep-2008 (A)
1-5	CD-4A (Approve *Accelerator* Project Completion and Start of Operations)	Dec-2014
1-6	CD-4B (Approve *Experimental Equipment* Project Completion and Start of Operations)	Sep-2017

Table 5.6
Project Management and Control Milestones Level 2
("A" indicates actual completion date)

Level and Number	Milestone Description	Completion Date
	Level 2	
	WBS 1.3 Accelerator	
2-01	Klystron Mass Production Authorization	Mar-2011(A)
2-02	Start Accelerator Installation Shutdown	May-2012 (A)
2-26	Accelerator Installation Complete (except for Box PS)	Dec-2013
2-03	Accelerator Commissioned	Sep-2014
2-25	Box Supply Installation Complete	Oct-2014
	WBS 1.4 Upgrade Halls A, B , & C	
2-04	Design Report on Superconducting Magnets	Sep-2007 (A)
2-05	Design Review of Superconducting Magnets	May-2008 (A)
2-06	Award First Superconducting Magnet Contract	Jul-2009 (A)
2-07	Start Installation for Existing Halls	Jun-2012 (A)
2-08	Hall-A, Equipment Installation Completed	Dec-2013
2-09	Hall-A Beam Commissioning Completed	Mar-2014
2-34	Hall B Torus Cold Mass Delivered	Sep-2014
2-28	Hall C HB Magnet Delivered	Sep-2014

Level and Number	Milestone Description	Completion Date
2-27	Hall C Q1 Magnet Delivered	Oct-2014
2-35	Hall B Solenoid Cryostated Cold Mass Delivered	Dec-2014
2-29	Hall C Dipole Magnet Delivered	Jun-2015
2-30	Hall C Q2 Magnet Delivered	Jul-2014
2-31	Hall C Q3 Magnet Delivered	Aug-2015
2-32	Hall C Equipment Installation Complete	Dec-2015
2-36	Hall B Equipment Installation Complete	Dec-2015
2-33	Hall C Beam Commissioning Complete	Mar-2016
2-37	Hall B Beam Commissioning Complete	Mar-2016
	WBS 1.5 Hall D	
2-10	Start Hall-D Installation	Nov-2010 (A)
2-11	Installation of Hall-D Solenoid Completed	Aug-2013 (A)
2-12	Hall-D Equipment Installation Completed	Sep-2014
2-13	Hall-D Beam Commissioning Completed	Dec-2014
	WBS 1.6 Civil	
2-14	Design of Conventional Facilities Completed	Sep-2008 (A)
2-15	Ready for Equipment – CHL Addition (RFE)	May-2010 (A)
2-16	Ready for Equipment – Hall-D (RFE)	Dec-2010 (A)
2-17	Accelerator Tunnel Extension Completed	Nov-2011(A)
2-38	Conventional Facilities Complete	Dec-2015
	WBS 1.7 Project Management	
2-18	Preliminary Hazard Assessment Submitted to DOE	Jun-2005 (A)
2-19	Environmental Assessment Completed	Jan-2007 (A)
2-20	Completion of Land Transfer	Oct-2007 (A)
2-21	PEP Issued	Nov-2007 (A)
2-22	OAPM EVMS Contractor Certification Review Complete	Dec-2007 (A)
2-23	Accelerator Safety Envelope (ASE) completed	Jun-2008 (A)
2-24	Safety Assessment Document (SAD) completed	Jun-2008 (A)

The baseline schedule planning was done based on the funding guidance as described in Section 5.2. A detailed resource loaded schedule, which highlights the critical path, was established. This baseline schedule was not adjusted following the receipt of ARRA funds and the subsequent reduction of projected FY10 and FY11 funding. The completed contract award milestones related to the ARRA-funded work are shown below in Table 5.7.

Table 5.7
Milestones for ARRA-Funded Work
("A" indicates actual completion date)

No.	Description	Completion Date
1	Award 4 Meter Dipole Magnet Subcontract	May 2009 (A)
2	Award Central Helium Liquefier 4.5K Coldbox Subcontract	Sep 2009 (A)
3	Award Quad Magnets Subcontracts	Jun 2009 (A)
4	Award Cryomodule Spaceframes Subcontract	Aug 2009 (A)
5	Award Cryomodules Vacuum Vessels Subcontract	Nov 2009 (A)
6	Award End Can Subcontract	Dec 2009 (A)
7	Award High-Voltage Cathode Power Supply Subcontract	Jan 2010 (A)
8	Award Central Helium Liquefier Compressors Subcontract	Mar 2010 (A)
9	Award Box Power Supply Subcontract	Mar 2010 (A)
10	Award North & South Access Building Subcontract	Jan 2010 (A)
11	Award Final Stimulus Subcontract	Sep 2010 (A)

6.0 Baseline Change Control Process

Baseline Change Control approval levels and thresholds listed in Table 6.1 control the project baseline. Approved Baseline Change Requests (BCRs) allow the modification of the baseline.

The project has established a process based upon the Jefferson Lab Project Control System Manual in which a Change Control Board (CCB) must approve all Level 3 and higher BCRs. The Change Control Board is chaired by the Contractor Project Manager with membership including the Deputy Project Manager and Associate Project Managers. The Integration Engineer, the Safety Manager and the Deputy Head of the Office of Project Management & Integration are advisors to the CCB. Level 4 and 5 BCRs are presented and discussed at the weekly CCB meetings for general information.

The FPD has approval authority on all Level 2 BCRs. The FPD's review/approval process will include input from the 12 GeV Executive Leadership, the NP 12 GeV Program Manager, and subject matter experts, as necessary. The FPD will keep the NP 12 GeV Program Manager informed on all Level 2 BCR actions.

Level 1 BCRs will be approved by the Associate Director for the Office of Nuclear Physics. The FPD will coordinate all Level 1 BCRs with the DOE Site Office Manager prior to submission to the NP 12 GeV Program Manager for action by the Associate Director. Upon receipt of a BCR, the NP 12 GeV Program Manager will be responsible for coordinating and receiving recommendations, including, if necessary, recommendations by an Independent Project Review team chaired by the Office of Project Assessment.

Baseline Change Requests resulting in Performance Baseline Deviations will be reviewed by an Independent Project Review team and, if necessary, an External Independent

Review team. Approval will be based in part from review team recommendations and other factors as appropriate.

The Integrated Project Team will receive information regarding BCR activities at all levels on a monthly basis, with all Deviations and at least all Level 1 through 3 activity described in the 12 GeV Monthly Report.

Additionally, when a contribution from a non-DOE funding source has benefited the project in terms of reduction of overall project cost or schedule within the defined scope, the NP 12 GeV Program Manager may direct that a re-baseline using the Change Control process is in order. Non-DOE scope will be tracked as part of WBS Level 1.10, Non-DOE Scope.

Revisions to this PEP that are required to incorporate baseline change control actions are considered to be approved by virtue of the corresponding baseline change control approval. Approval of, and revisions to this PEP that are not associated with baseline change controls have been delegated to the 12 GeV Federal Project Director (FPD). The 12 GeV FPD is authorized to approve non-substantive changes to the PEP and to update the document with the appropriate factual material (i.e., dates that project milestones are completed, approved baseline changes) without higher-level approval. Changes to this PEP will be coordinated between the 12 GeV FPD, the Jefferson Lab 12 GeV Project Manager and the NP 12 GeV Program Manager.

Table 6.1
Baseline Change Control Thresholds

	Performance Baseline Deviations	**Routine Project Changes**		
	Acquisition Executive (SC-2) (Level 0)	**SC Associate Director (Level 1)**	**Federal Project Director (Level 2)**	**Contractor Project Manager (Level 3)**
Technical Scope	Any change in scope and/or performance that affects mission need requirements or is not in conformance with current approved Project DataSheet	Any change that positively affects CD-4 Deliverables as identified in PEP Section 5.1	N/A	Any significant change in the System Requirements Document
Schedule	Any change to CD-4B Project Completion Date	≥ 3 month change to a Level 1 Milestone (except for CD-4B) listed in PEP Table 5.5	Any use of schedule contingency that extends the critical path or changes to a Level 1 Milestone (PEP Table 5.5) less than 3 months (except for CD-4B), or any change to a Level 2 Milestone (PEP Table 5.6)	Any change to a Level 3 Milestone > 3 months
Cost	Any increase to CD-2 TPC baseline	Any change to CD-2 baseline TEC or OPC	Any use of contingency, and cumulative change, plus or minus ≥ $2M of any WBS Level 2 cost element	Any cumulative change at WBS Level 2 < $2M that does not use contingency

7.0 Analysis, Assessments and Plans

7.1 Acquisition Strategy

The choice of the acquisition approach is mainly dictated by the nature of the project. With the exception of Hall D, the project is an integrally coupled upgrade of the existing CEBAF. Therefore, it cannot be easily decoupled from the operating contractor without introducing significant project interface requirements and associated additional project costs and inefficiencies. All acquisitions will be managed by JSA with appropriate DOE oversight. Cost, schedule and technical performance will be monitored using an earned-value process that is described in the Jefferson Lab Project Control System Manual. Jefferson Lab's standard procurement practice is to use firm fixed-price purchase orders and subcontracts for supplies, equipment and services, and to make awards through competitive solicitations where possible. Additional details related to the acquisition approach can be found in the 12 GeV CEBAF Upgrade Acquisition Strategy that was approved by the Acquisition Executive (AE) in February 2006. Note that the information regarding the project cost and schedule contained in the Acquisition Strategy is superseded by the updated information in this PEP.

Table 7.1 shows the twelve planned major procurements whose total contract award will exceed $2M (FY08 direct dollars). For most of these procurements, the contract will have a duration of two to four years. The anticipated initial obligation date and contract duration are included in Table 7.1.

Table 7.1
Planned Major Procurements > $2M

WBS	Major Procurement	Initial Obligation Date	# Years in Contract	Re-Bid Obligation Date
1.5.2.2.1	Hall D: BCal Scintillating Fibers	1QFY09 (A)	3	NA
1.6.3.1	Civil: Hall D Construction	2QFY09 (A)	3	NA
1.3.2.1.1	Power - Klystrons	3QFY09 (A)	2	NA
1.3.1.1.1	Cryomodules - Cavity Fabrication	4QFY09 (A)	1	NA
1.3.4.2.	Beam Transport - Dipole	3QFY09 (A)	1	NA
1.3.4.2.	Beam Transport - Quads	3QFY09 (A)	1	NA
1.4.2.1.1	Hall B CLAS12: Torus Magnet	4QFY09 (A)	4	4QFY12(A)
1.3.3.1.2	CHL 4.5K Refrigerator Cold Box	4QFY09 (A)	1	NA
1.4.2.1.2	Hall B CLAS12: Solenoid Magnet	1QFY10 (A)	3	1QFY13(A)
1.3.3.1.1	CHL Helium Compressors	2QFY10 (A)	1	NA
1.4.3.1.3	Hall C SHMS: Q2/Q3 Magnets	1QFY11 (A)	2	NA
1.4.3.1.4	Hall C SHMS Dipole Magnet	4QFY10 (A)	3	NA

7.2 Project Risk Management

The IPT expects the project risk to be managed according to the formal 12 GeV CEBAF Upgrade Risk Management Plan. Levels of risk are identified by each WBS subsystem manager for their respective WBS level 3 scope based on the probability of occurrence and the potential impact to the project performance, cost, and schedule. These assessments are reviewed by the 12 GeV project management team and classified as overall either low, moderate, or high.

Overall the technical risk of the 12 GeV CEBAF Upgrade is categorized as low. Most of the technology for the accelerator, conventional construction, and experimental equipment is already in use at Jefferson Lab and based on proven technologies. This project is being designed to utilize the SRF expertise unique to Jefferson Lab which has been developed during the lifetime of the laboratory. As this project and others requiring SRF technology are high on the priority list of DOE and the nuclear physics community, it is expected that this core competency will continue to be supported at Jefferson Lab. A 12 GeV CEBAF Upgrade R&D Plan has been developed and is being carried out to mitigate any risk associated with remaining open technical issues and to achieve further cost optimization where possible.

The Contractor Project Manager and the FPD in coordination with the IPT will manage the cost and schedule risk. Contingencies have been estimated for each part of the project, and schedule float is incorporated in the project plan. Progress will be carefully monitored and compared with the plan. Deviations from the plan will be corrected and/or will be charged to the project's contingency budget or Contractor management reserve. Management reserve is managed and controlled by the 12 GeV Upgrade Project Manager. The overall cost and schedule risk are categorized as low. Consistent with the Risk Management Plan, periodic review of risk elements including their relationship to remaining contingency and the status of risks and management activities will be conducted monthly as a minimum. Further details on risk management are in the 12 GeV Risk Management Plan.

The project schedule and plans presented at the time of CD-2 were dependent upon the project funding profile identified in the CD-2 documentation. Table 5.4 provides the current funding profile matching the rebaseline of the project in response to the directed change to the FY 2012 allocation. Should the funding profile change again in the future, another formal re-baseline of the project may be required.

7.3 Value Engineering

Value Engineering (VE) studies were conducted throughout the conceptual design and PED phases of the project, and will continue during the Construction phase of the project. On select portions of the design, the Project organized review panels consisting of independent reviewers plus appropriate members of the project team who evaluated alternative design approaches keeping the performance goals in mind. The various VE studies determined the impact of alternative approaches on the project cost and schedule

including post completion operating and maintenance costs. The teams also considered the adaptability of the various designs for future upgrades of the facility.

The Value Engineering approach was incorporated into the technical reviews. During the conceptual design phase, Jefferson Lab convened several external panels for technical design reviews: 1) Hall D electronics and data acquisition, 2) Hall D detectors, 3) Halls A and C spectrometer designs, and 4) a cryomodule design review. After the start of PED, Jefferson Lab convened external panels for the following technical design reviews: 1) Hall D tagger system, 2) Halls B and C superconducting spectrometer magnets, 3) accelerator arc magnets, 4) Halls B and D drift chamber detectors, 5) Hall B preshower calorimeter and low threshold Cerenkov counter, and 6) civil construction of Hall D complex. In addition, the Jefferson Lab Program Advisory Committee (PAC) in January 2005 reviewed the plans for the experimental equipment and its suitability for delivering the proposed scientific capabilities. This was followed in summer 2006 and summer 2007 with PACs dedicated to reviewing proposals for the commissioning experiments for the upgraded facility. The development of the project R&D plan has also included VE concepts resulting in a focus on design optimization to achieve cost effectiveness while maintaining performance requirements.

7.4 Environment, Safety, Health and Security

All phases of the 12 GeV CEBAF Upgrade project will be carried out in accordance with the Jefferson Lab Environment, Health and Safety (EH&S) policies and procedures as documented in the Jefferson Lab "EH&S Manual" including obeying all local, state and federal regulations. The laboratory has as one of its guiding principles, the protection of the health and safety of its employees, contractors and the public. With the exception of the Hall D complex, construction will take place in existing developed areas (e.g., accelerator tunnel, Halls A/B/C, CHL, and N&S Access Buildings). Impacts to the environment are anticipated to be minimal. Disturbance to land and modification to other buildings will be minimal with respect to environmental impact, and mitigating measures will be taken as appropriate. In compliance with the National Environmental Policy Act (NEPA), an Environmental Assessment (EA) was developed for this project and other items in the Jefferson Lab Ten Year Site Plan. A Finding of No Significant Impact (FONSI) was approved on January 30, 2007 by the TJSO Site Manager.

The work to be conducted at the Jefferson Lab site will be covered under the laboratory's existing Integrated Safety Management (ISM) Program. ISM is an integral part of Jefferson Lab's management structure. This is spelled out in detail in the "EH&S Manual", the "Quality Assurance Manual", and various management manuals and training documents. A "12 GeV Construction Project Safety and Health Plan" has been developed and approved by the TJSO Site Manager.

An ES&H representative from the Site Office and from the Jefferson Lab ESH&Q Division are members of the IPT SME. Jefferson Lab has a history of performing similar accelerator, detector and conventional construction in a safe manner. In addition, a "Hazard Assessment" specific to the 12 GeV CEBAF Upgrade project was prepared as

part of the required CD-2 documentation in support of sustained operations. The environmental, safety, and health risks/issues are considered small and manageable with current standard processes.

Safeguards and security will be covered under Jefferson Lab's existing DOE-approved program and the laboratory has experienced no major incidents in the past. The 12 GeV CEBAF Upgrade does not add any additional security requirements that are not already addressed by current Jefferson Lab policies and procedures. The safeguards and security issues are considered small and manageable with standard practices. A Security Risk Assessment for Jefferson Lab was conducted in February 2007 that also addressed the 12 GeV Upgrade Project. The report was issued in April 2007. In a memo dated April 24, 2007, the TJSO Security Program Manager indicated that the "..Security Risk Assessment...serves as the Security Vulnerability Assessment Report for the 12 GeV CEBAF Upgrade Project."

7.5 Sustainable Building Design

The building design process will utilize sustainable building design principles and will involve maintenance and operations personnel during reviews. The preliminary design of buildings will be evaluated against the U.S. Green Building Council's LEED (Leadership in Energy & Environmental Design) design goals. Energy and water conservation, minimization of waste, and use of recycled and recyclable materials are the major areas of focus because most of the new space houses equipment versus personnel. Procurement documents will incorporate waste disposal and recycle requirements. The Project will not be seeking LEED certification.

7.6 Configuration Management

Configuration of the project baseline documents will be maintained using the formal change control process described in Section 6 and detailed in the "Jefferson Lab Project Control System Manual." These documents are listed below:

- Project Data Sheet,
- Project Execution Plan,
- Systems Requirements Document,
- Systems Design Packages,
- Sub-system Design Packages,
- Construction Design Packages, and
- Approved Baseline Change Proposals.

7.7 Quality Assurance

Quality Assurance is an integral part of effective project management and will be employed throughout the design, procurement, and construction of the 12 GeV CEBAF Upgrade. Particular planning and attention will be given to those items which have the greatest potential to impact the project cost, schedule, and performance. Extensive testing and evaluation will be carried out for all of the critical components whether purchased or fabricated and assembled in house. Components and subsystems such as

the CHL, RF stations, magnets, detector elements, and power supplies will be tested off-line as appropriate prior to installation. Quality will be assured in accordance with the Jefferson Lab "Quality Assurance Manual." National codes and standards will be followed throughout. These practices have been used and honed at Jefferson Lab for many years on both CEBAF and the Free Electron Laser effort. In addition, a 12 GeV Supplemental Quality Assurance Plan (SQAP) has been developed that is consistent with the Jefferson Lab manual.

8.0 Energy Conservation and Life Cycle Cost Analysis

The total life cycle cost (TLCC) for the 12 GeV CEBAF Upgrade is estimated at $2.70 billion over the anticipated 15-year useful life span. When performing the life cycle cost analysis, the sum total of direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred over the anticipated useful life span was considered.

More specifically, the TLCC includes the TPC ($338 million) of the 12 GeV CEBAF Upgrade Project. The operations and maintenance (O&M) costs makes up the balance of the TLCC costs. The O&M costs were based on past experience and are estimated to increase operations by approximately $15 million in FY2017 dollars. Escalating the total O&M costs at approximately 4% per year for the life span of the science program, the average annual cost of ~$150 million was determined. Therefore, over the program's life span, O&M is estimated at ~$2.25 billion. Though substantial, almost 90% of this O&M is associated with the cost of operating the existing 6 GeV accelerator.

Any estimate of D&D cost is highly dependent upon what assumptions are made about reuse of equipment and facilities at Jefferson Lab, amount of material recycled, and degree of contaminated material. There is the possibility that the machine would undergo another major upgrade in the future and the experimental equipment would be reused rather than decommissioned. The remaining equipment would be removed and it is expected that these activities should be routine and relatively modest in cost. Though estimated at approximately $5 million to $10 million, this cost was considered absorbed in the rounding up of the total O&M cost estimated above.

The Value Engineering Study described in Section 7.3 will include a review of the estimated operating costs. These will include the cost of energy as well as the replacement of parts and subsystems. It is expected that any improvements in energy use or maintenance costs, which do not compromise performance, will be incorporated in the final design.

9.0 Project Controls and Reporting Systems

Cost, schedule and technical performance will be monitored using an earned-value process that is described in the Jefferson Lab Project Control System Manual. Contingency percentage will be tracked monthly and be defined as the ratio of unallocated Contingency divided by the Estimate to Complete (ETC). The Variance

Report threshold for Level 2 cumulative deltas will be 10% **and** $50K for "Yellow", 20% **and** $100K for "Red".

The size of the project requires that the Contractor's Earned Value Management System (EVMS) be certified by OAPM. A certification review took place at Jefferson Lab in December 2007 with data from the 12 GeV CEBAF Upgrade providing the primary material. A Corrective Action Plan was completed and validated by OAPM. Certification of the Jefferson Lab EVMS system was completed in September 2008. Then in May 2012, Jefferson Science Associates was notified that they successfully completed a DOE EVMS Acceptance Review Process. As a result of the review and the corrective actions taken since that time, the Review Committee determined that the EVMS is deployed to be compliant and meets the requirements of the American National Standard Institute / Electrical Industries Alliance (ANSI/EIA)-748B

The Change Control process is documented in Section 6.0 of this PEP. Frequent management oversight/visibility (up to the Acquisition Executive, SC-2) will be achieved through established mechanisms. These mechanisms include:

- **IPT Meetings:** The core IPT meets bi-weekly to address Project leadership actions and issues. Members of the IPT Executive Leadership (i.e. SC-26 / Acting Deputy for Programs, SC-2 / DOE Site Office Manager, and JLab Director) and/or Subject Matter Experts (i.e. Safety Manager, Integration Engineer, and Procurement Manager), may attend meetings depending on availability or they may be specifically asked to attend to address specific concerns/issues.

- **Situational Meetings:** If deemed necessary, key individuals meet on a regular basis to address major concerns. The frequency, duration, and attendance of these meeting are dependent on the situation. However, they generally involve the core IPT members, members of the IPT Executive Leadership, and/or Subject Matter Experts.

- **12 GeV Monthly Progress Reports and Meetings:** The project prepares monthly progress reports and monthly status reports. The IPT holds monthly meetings that include the core team members, SC Office of Project Assessment and SC Executive Leadership. These reports and meeting discussions highlight progress in terms of risk, level 1 and 2 milestones, change control activities, spending to date, and major highlight activities. When the 12 GeV Project was baselined, the report and meeting format was enhanced to include detailed earned value management reporting information.

- **Project Analysis and Reporting System (PARS II):** Project performance is entered monthly into PARS II as required by OAPM. Once the 12 GeV project was baselined, the earned value management data became a requirement for the PARS II report. Using the PARS II information, quarterly reports, project review reports (EIRs, IPRs), and discussions with program and project managers, OAPM independently provides an overall project assessment (Green, Yellow, or Red).

OAPM prepares a presentation package that is sent each month to the Deputy Secretary for DOE to outline the status of all projects to raise management involvement.

- **Quarterly Project Progress (QPP) Reports:** QPP Reports are issued the month following the end of the fiscal quarter. The QPP Reports include overall project summary assessment; funding to date; contingency to date; schedule summary; milestone/significant accomplishments; milestone/significant activities upcoming; project highlights; and a detailed cost report including earned value management data at the WBS level 2.

- **Annual Reviews by SC Office of Project Assessment:** Each year, the Office of Nuclear Physics charges the Office of Project Assessment to evaluate through an independent project review, progress of the 12 GeV project. Reports summarizing these reviews are developed, including a debriefing by the Office of Project Assessment to the Acquisition Executive on the outcome of the review.

10.0 Alternatives

Various project scopes were evaluated, including the risk of doing nothing. Maintaining the status quo and not performing the upgrade means that the U.S. Nuclear Physics program will lose its world leadership in the study of hadronic matter. Significant investment has been made in the present facility with planning that incorporated a cost-effective upgrade to provide scientific forefront capabilities and maintain this leadership for the next decade and beyond. Enhancing the capability of CEBAF can be realized for a fraction of the replacement cost of the facility, particularly given facility improvements over the past decade. There is no other facility in the world at which this project could be located. This project will reduce cost by using the existing systems, facilities, and experience at Jefferson Lab instead of building a new facility with the same requirements at another location. The CEBAF upgrade alternative was chosen because it was more cost effective than building a new facility. The Nuclear Physics program would either support this upgrade at Jefferson Lab, or not embark on this project. Without this upgrade the scientific impact of continued operation of CEBAF would have to be evaluated in the context of other opportunities across the Nuclear Physics program.

11.0 Transition to Operations

Transition to Operations or “Commissioning” will be done in stages and is expected to start approximately four and a half years after Critical Decision-3 (CD-3). Also, a 'Project Transition to Operations Plan' will be developed in support of CD-4A. The commissioning of the experimental equipment in the Halls will be complete by Milestone CD-4B, the formal completion of the 12 GeV Upgrade project. A Start-Up Test Plan, consistent with this stage of the design maturity, addressing the check-out and commissioning plans was developed in support of CD-2 Approval. The Start-Up Test Plan was the basis for the *Preliminary Checkout, Testing, and Commissioning Plan* which was developed in support of CD-3. Commissioning will include (but not be limited to):

- System studies (e.g., vacuum, cryogenic, RF, controls, power-supply),
- Acceleration studies,
- Transmission to each of the experimental halls in turn,
- Spectrometer magnet ramping exercises, and
- Detector checkout with pulsers, cosmic rays, and beam.

Appendices

A. Acronym List
B. WBS Dictionary

Appendix A: ACRONYM LIST

AE	Acquisition Executive
A/E	Architect Engineer
ACD	Advanced Conceptual Design
AD	Associate Director
APM	Associate Project Manager
ARRA	American Recovery and Reinvestment Act
ASE	Accelerator Safety Envelope
BCP	Baseline Change Proposal
BCR	Baseline Change Request
CAM	Control Account Manager
CCB	Change Control Board
CD	Critical Decision
CDR	Conceptual Design Report
CEBAF	Continuous Electron Beam Accelerator Facility
CHL	Central Helium Liquefier
CLAS	CEBAF Large Acceptance Spectrometer
CLAS12	CEBAF Large Acceptance Spectrometer for 12 GeV CEBAF Upgrade
COR	Contracting Officer Representative
CPM	Contractor Project Manager
CR	Continuing Resolution
D&D	Decommissioning and Disposal
DCD	Design Criteria Document
DOE	Department of Energy
DOE-NP	DOE Office of Nuclear Physics
DSD	Design Solution Document
EA	Environmental Assessment
EH&S	Environment, Health and Safety
ES&H	Environment, Safety and Health
ESH&Q	Environment, Safety, Health and Quality
ETC	Estimate to Complete
EVMS	Earned Value Management System
FEL	Free Electron Laser

FONSI	Finding of No Significant Impact
FPD	Federal Project Director
FPSC	Fixed-Price Subcontractors
FY	Fiscal Year
GeV	Giga (or billion) electron volts
GV	Giga (or billion) volts
HA	Hazard Assessment
HMS	High Momentum Spectrometer
I&C	Instrumentation and Controls
ICD	Interface Control Document
IPT	Integrated Project Team
ISM	Integrated Safety Management
JLab	Thomas Jefferson National Accelerator Facility (Jefferson Lab)
JSA	Jefferson Science Associates, LLC
LCC	Life Cycle Cost
LCCA	Life Cycle Cost Analysis
LCW	Low Conductivity Water
LEED	Leadership in Energy and Environmental Design
LLC	Limited Liability Corporation
NEPA	National Environmental Protection Act
NP	Office of Nuclear Physics
NSAC	Nuclear Science Advisory Committee
NSF	National Science Foundation
N&S	North and South
OAPM	Office of Acquisition & Project Management
OPA	Office of Project Assessment
OPC	Other Project Costs
PARS	Project Assessment and Reporting System
PED	Project Engineering and Design
PEP	Project Execution Plan
PM	Project Manager
PMIP	Project Management and Integrated Planning
QPP	Quarterly Project Progress
R&D	Research and Development

RFE	Ready For Equipment
SAD	Safety Assessment Document
SC	DOE Office of Science
SHMS	Super High Momentum Spectrometer
SME	Subject Matter Expert
SQAP	Supplemental Quality Assurance Plan
SRD	System Requirement Document
SRF	Superconducting Radio Frequency
TEC	Total Estimated Cost
TJNAF	Thomas Jefferson National Accelerator Facility (Jefferson Lab or JLab)
TJSO	Thomas Jefferson Site Office
TPC	Total Project Cost
VE	Value Engineering
WBS	Work Breakdown Structure

Appendix B: WBS Dictionary

Following is a table of significant WBS dictionary entries. The full WBS dictionary is mapped to the project Costbook and is a stand-alone document.

WBS	Description	Dictionary
1	12 GeV Upgrade to CEBAF	CEBAF Upgrade to 12 GeV, New Hall D, Halls A,B,C Upgraded to 11 GeV.
1.0	CDR/ACD	Conceptual and Advanced Design for 12 GeV Upgrade
1.1	R&D	Research & Development to develop design solutions that meet performance goals while optimizing cost and schedule
1.2	PED	Project Engineering and Design for 12 GeV Upgrade
1.2.1	PED Accelerator Systems	Engineering and design of all Accelerator Systems
1.2.1.1	PED Accel Systems Cryomodules	Project Engineering and Design for Cryomodules
1.2.1.2	PED Accel Systems Power Systems	PED Rollup of RF and Magnet System Equip and Installation
1.2.1.3	PED Accel Systems Cryogenics	Engineering and design and document development for cryogenics systems
1.2.1.4	PED Accel Systems Beam Transport	E&D phase of upgrading beam transport system for accelerator
1.2.1.5	PED Accel Systems Extraction	PED for Extraction system which encompasses RF Separator cavities and controls as well as the development of magnet systems that are specifically part of extracting beams
1.2.1.6	PED Accel Systems Instrumentation, Controls, and Safety Systems	Procurements and engineering, technician and software manpower for Engineering Design for beam diagnostics, feedback, control system infrastructure, machine protection system, personnel safety system, instrumentation and controls for dumps, vacuum and mag
1.2.2	PED Upgrade Hall A, B & C	Project Engineering and Design for Halls A, B, and C
1.2.3	PED Hall D	PED for all equipment and auxiliary support required to operate the GlueX detector in Hall D
1.2.4	PED Conventional Facilities	Engineering and design of new conventional facilities and modifications to existing conventional facilities to support the 12 GeV CEBAF Upgrade

1.2.5	PED Project Management	Project Management support for PED phase of 12 GeV Upgrade
1.2.6	PED Accelerator Systems Commissioning Planning	Development of Accelerator Commissioning Plan
1.3	Construction Accelerator Systems	This summary WBS covers the development of the cryomodules, power systems, cryogenic systems, beam transport systems, extraction systems, and instrumentation, controls, & safety systems of the 12 GeV Upgrade accelerator.
1.3.1	Construction Accel Systems Cryomodules	This summary WBS covers the procurement, assembly, testing and installation of the 10 new accelerator cryomodules.
1.3.2	Construction Accel Systems Power Systems	This summary WBS covers the equipment and installation of the accelerator RF and magnet power systems.
1.3.3	Construction Accel Systems Cryogenics	This summary WBS covers the construction phase of upgrading the cryogenics system.
1.3.4	Construction Accel Systems Beam Transport	This summary WBS covers the construction phase of upgrading the beam transport system for the accelerator.
1.3.5	Construction Accel Systems Extraction	This summary WBS covers the construction for the extraction system which encompasses RF separator cavities and controls as well as the development of magnet systems that are specifically part of extracting beams.
1.3.6	Construction Accel Systems Instrumentation, Controls, and Safety Systems	This summary WBS covers the procurements, fabrication, construction, installation and testing for beam diagnostics, feedback, control system, machine protection system, personnel safety system, instrumentation and controls for dumps, vacuum and magnets in support of the 12 GeV Upgrade.
1.4	Construction Upgrade Hall A, B & C	This summary WBS covers the Halls A, B, C construction for the 12 GeV Upgrade.
1.4.1	Construction Hall A	This summary WBS covers the Hall A construction for 12 GeV Upgrade and includes the beamline equipment upgrade.
1.4.2	Construction Hall B	This summary WBS covers the Hall B construction for the 12 GeV Upgrade: Detectors (central Time-of-flight, barrel silicon vertex tracker, high threshold Cerenkov counter, six sectors of threw regions of drift chambers, six sectors of two panels of time-of-flight system, six sectors of preshower calorimeter six sectors of refurbished low threshold Cerenkov counter, Superconducting Magnets (superconducting Torus, superconducting solenoid), electronics, data acquisition and CLAS12 trigger system, upgrade beam-line and finally assembly and installation of all components of the CLAS12.
1.4.3	Construction Hall C	This summary WBS covers the Hall C construction for 12 GeV Upgrade: SHMS magnetic spectrometer with accompanying detectors, electronics, assembly and installation. The SHMS has 5 superconducting

		magnets with a DQQQD design that will be capable of resolving particles up to 11 GeV/c in momentum. This device achieves 4.5 msr, acceptance at bend angles from 5.5 degrees to 40 degrees by using five magnetic elements.
1.5	Construction Hall D	This summary WBS covers the Hall D construction for the 12 GeV Upgrade. The GlueX detector will be housed in a new above-ground experimental hall (Hall D) located at the east end of the CEBAF north linac. A collimated beam of linearly polarized photons (with 40% polarization) of energy 8.5 to 9 GeV will be produced via coherent bremsstrahlung with 12 GeV electrons. This requires a very thin diamond crystal radiator and a 3.5 mm collimator 75m downstream of the radiator to achieve the designed polarization. The GlueX detector uses an existing 2.2 T superconducting solenoid that is currently being refurbished. An existing 2800-element lead-glass electromagnetic calorimeter for detecting photons will be reconfigured to match the downstream aperture of the solenoid. Immediately upstream is located a scintillator hodoscope for triggering and for use in time-of-flight (TOF) measurements. The barrel calorimeter, which lines the inside of the solenoid and consists of alternating layers of lead and scintillating fibers bonded together with optical epoxy, will provide position and energy measurement for photons and flight time information for charged particles. A start counter will surround the 30 cm long liquid hydrogen target. This counter will be surrounded by cylindrical straw-tube drift-chambers, which will fill the region between the target and the barrel calorimeter. Planar drift chambers will be placed inside the solenoid downstream of the target to provide accurate track reconstruction for charged particles going in the forward direction. This detector configuration has close to a 4π hermeticity and momentum/energy and position information for charged particles and photons produced from incoming 9 GeV photons. In particular, the geometrical acceptance of the detector for final state particles is typically above 95% and is quite uniform over the detector.
1.6	Construction Conventional Facilities	This summary WBS covers all the effort to construct new conventional facilities and modify existing conventional facilities in support of the 12 GeV CEBAF Upgrade.
1.6.1	Construction Conventional Facilities Accelerator	This summary WBS covers all the effort to modify existing buildings and utility systems to support CEBAF operations at 12 GeV.
1.6.2	Construction Conventional Facilities CHL	This summary WBS covers all the effort to modify the existing CHL building and utility systems to support the new CHL #2 operations.
1.6.3	Construction Conventional Facilities Hall D	This summary WBS covers all the effort to construct new conventional facilities to house the Hall D experimental equipment including the beam transport line and to support operations of Experimental Hall D. Referred to as the Hall D

		Complex.
1.7	Construction Project Management	This summary WBS covers the management services required for the execution of the construction upgrade plan and schedule.
1.7.1	Construction Project Management Project Office	This WBS element includes the project management for the construction phase of the upgrade project: Project Manager, Deputy Project Manager, Safety Manager, Safety Inspector, Integration Engineer, Associate Project Managers, , and Administration support staff.
1.7.2	Construction Project Management & Integration Office	This WBS element includes the level of effort activity of the project management and integration office for the construction phase of the upgrade project. Costs for this activity have been moved to WBS 1.10 since they are funded through non-DOE sources.
1.8	Construction Pre-Ops	This summary WBS covers the pre-operations phase, including checkout, "hot checkout" periods and commissioning with beam periods. Hot checkout periods involve the last stages of checkout of all devices related to beam delivery and associated diagnostics, and is typically done just before accelerator/Hall close-up for beam delivery.
1.8.1	Construction Accelerator Pre-Ops	This summary WBS covers the checkout, hot checkout and beam commissioning of the accelerator.
1.8.2	Hall Pre-Ops	This summary WBS covers the checkout, hot checkout and beam commissioning of Halls A, B, C, and D.
1.8.3	Pre-Ops Support	This summary WBS covers the management services required for the execution of the pre-ops upgrade plan and schedule.
1.9	12 GeV – Work for Others (WFO)	This WBS element covers use of Work for Others funds to support construction of certain elements of the 12 GeV project.
1.10	Non DOE Scope	Scope to be moved to this WBS element as MOAs are developed