Kovar

Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

March 31, 2009

MEMORANDUM FOR KYLE E. MCSLARROW
DEPUTY SECRETARY

THROUGH: ROBERT G. CARD
UNDER SECRETARY

JAMES T. CAMPBELL
ACTING DIRECTOR, MANAGEMENT BUDGET, AND EVALUATION/CHIEF FINANCIAL OFFICER

FROM: RAYMOND L. ORBACH
DIRECTOR
OFFICE OF SCIENCE

SUBJECT: ACTION: Approval of the Mission Need (CD-0) for the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade at Thomas Jefferson National Accelerator Facility (TJNAF).

ISSUE: Per DOE Order 413.3 and DOE Manual 413.3-1, the Office of Nuclear Physics is requesting approval of a Mission Need (Critical Decision - 0 (CD-0)) for a new Office of Science construction project that will double CEBAF's beam energy from the current operating value of 6 GeV to 12 GeV in a very cost-effective manner.

BACKGROUND: The CEBAF Upgrade will take advantage of recent advances in computing power and an increase in energy to a 12 GeV electron beam to provide much more precise data on the structure of protons and neutrons. Specifically, the upgrade will enable scientists to address one of the great mysteries of modern physics – the mechanism that "confines" quarks together. New supercomputing studies indicate that force fields called "flux-tubes" may be responsible, and a 12 GeV electron beam is required to excite them, which should lead to the creation of never-before-seen particles. Jefferson Laboratory is proposing to upgrade the accelerator, construct a new hall and beam-line, and upgrade and/or add new equipment in the existing experimental halls. The Upgrade has the support of a large and active user community (~1,200 scientists from 29 countries).

The attached Mission Need Statement addresses the 12 GeV CEBAF Upgrade at TJNAF, whose scientific program and technical concept has been thoroughly reviewed by the Department of Energy/National Science Foundation (DOE/NSF) Nuclear Science Advisory Committee (NSAC), which recommends the 12 GeV Upgrade as one of its highest priorities in the 2002 Long-Range Plan. In addition, the Office of Science's *Facilities for the Future of Science, A Twenty Year Outlook*, identifies the 12 GeV Upgrade as a near-term rank seventh priority facility. This plan, endorsed by Secretary Abraham at his November 10, 2003 press conference, was developed with input from all the relevant stakeholders throughout the physical sciences and outlines the Office of Science's future scientific initiatives and priorities.

The estimated Total Project Cost of this construction project is 170 – 250 million dollars. The FY 2005 Congressional Budget request includes funds for R&D and conceptual design for this project.

The Office of Program Analysis and Evaluation (ME-20) has reviewed the Mission Need Statement and recommended its approval. In addition, the Office of Science held an ESAAB Equivalent Review on January 15th, 2004, and they also recommended approval of the Mission Need (CD-0). Although I have been delegated the authority to approve this Mission Need decision, I am proposing that you approve this CD-0 because of the importance of the 12 GeV Upgrade to the Department's Mission. Approval of CD-0 will authorize the preparation of a conceptual design for this project. Per DOE Order 413.3 and DOE Manual 413.3-1, as the Acquisition Executive, I have approved the attached Mission Need Statement and maintain authority to approve all subsequent Critical Decisions.

RECOMMENDATION: The proposed Mission Need has been thoroughly reviewed and supported by ME-20 and the ESAAB Equivalent Board. It is recommended that the Deputy Secretary approve the 12 GeV Upgrade Mission Need (CD-0) by signing below.

Approve: _____

Disapprove: _____

Date: 3/31/04

Attachment

Statement of Mission Need for the 12 GeV CEBAF Upgrade at Thomas Jefferson National Accelerator Facility

Non-Major Systems Acquisition

Submitted August 13, 2003

Originator: **Dennis Kovar**
301-903-3613
Associate Director of the Office of Science for Nuclear Physics

CONCURRENCES:

Jehanne Simon-Gillo
Program Manager for Facilities and Instrumentation,
Office of Nuclear Physics
Office of Science

Date: 8/13/03

Dennis Kovar
Associate Director of the Office Science
for Nuclear Physics

Date: 8/14/03
8/25/03

Daniel R. Lehman
Director, Construction Management Support Division
Office of Science

Date: 8/26/03

APPROVED:

Raymond L. Orbach
Director, Office of Science

Date: JAN 20 2004

Mission Need Statement
for the
12 GeV CEBAF Upgrade
at Thomas Jefferson National Accelerator Facility

Office of Nuclear Physics
Office of Science

SYSTEM POTENTIAL: Non-Major System

A. Statement of Mission Need

The mission of the Nuclear Physics (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 Department of Energy's (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 Nuclear Physics mission areas under the mandate provided in Public Law 95-91 that established the Department.

Thomas Jefferson National Accelerator Facility (TJNAF), also known as Jefferson Laboratory, was constructed, and is now operated by the Nuclear Physics program. The centerpiece of TJNAF is the Continuous Electron Beam Accelerator Facility (CEBAF), a unique international electron-beam user facility. Jefferson Laboratory is proposing to double CEBAF's beam energy from the current operating value of 6 GeV to 12 GeV in a very cost-effective manner. CEBAF consists of two superconducting linear accelerators and three experimental halls. Jefferson Laboratory is proposing to upgrade the accelerators, construct a new hall and beamline, and upgrade and/or add new equipment in the existing experimental halls.

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 also supports two Science strategies within the Department of Energy's Draft Strategic Plan dated August 6, 2003. The strategies are: *1. Advance the fields of high-energy and nuclear physics, including the understanding of ...the basic constituents of matter...* and *7. Provide the Nation's science community access to world-class research facilities....* These two strategies are in support of the Department's Science Strategic Goal: *To protect our National and economic security by providing world-class scientific research capacity and advancing scientific knowledge.*

In the area of nuclear science, the scientific justification and need for increasing the energy of the TJNAF accelerator were strongly endorsed in the 2002 Nuclear Science Advisory Committee (NSAC) report *Opportunities in Nuclear Science: A Long-Range Plan for the Next Decade*. NSAC provides advice to DOE and the National Science Foundation (NSF) by identifying compelling scientific opportunities and recommending priorities through a Long Range Planning Process that incorporates input from the entire community. In the 2002 Long Range Plan, NSAC recommends the 12 GeV Upgrade as one of its highest priorities: "We strongly recommend the upgrade of CEBAF at Jefferson Laboratory to 12 GeV as soon as possible. The 12 GeV upgrade of the unique CEBAF facility is critical for our continued leadership in the experimental study of hadronic matter. This upgrade will provide new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon description of matter, and the nature of quark confinement."

B. Analysis to Support Mission Need

Nuclear Physics began by studying the structure and properties of atomic nuclei as assemblages of protons and neutrons. Great benefit, especially to medicine, emerged from these efforts. But today, nuclear physics extends from the quarks and gluons that form the substructure of the once-elementary protons and neutrons, to the most dramatic of cosmic events—supernovae. At its heart, nuclear physics attempts to understand the composition, structure, and properties of atomic nuclei.

Protons and neutrons, collectively called nucleons, are the building blocks of nuclear matter and thus form the heart of all atoms in the universe -- the star-stuff we are made from. But nucleons are themselves composed of quarks bound together by gluons, the "force carriers" (called bosons) that transmit the strong nuclear force. The nucleus is an ideal system to study the strong interaction, which can be described by a process called Quantum Chromodynamics or QCD.

To understand nucleon structure, one area of nuclear physics research is to probe quark confinement inside the nucleon. "Quarks" are the particles of which three unite to form protons and neutrons, which, with electrons, combine to form the atoms that make up all the matter that we are familiar with. Although protons and neutrons can be separately observed, their quark constituents can't be, because they are permanently confined inside the nucleons. While the mechanism of quark confinement is qualitatively explained by QCD, a quantitative understanding remains one of mankind's great intellectual challenges.

As yet, scientists are unable to explain the properties of even the basic neutrons and protons—why, for example, we do not seem to be able to "see" individual quarks in isolation (they change their natures when separated from each other) or understand the full range of possibilities that can make up matter. However, since its completion in 1995, CEBAF has played a unique, world-leadership role in nuclear physics, providing essential insights into the fundamental structure of matter, including the recent discovery of a "pentaquark" composed of five bound quarks. The proposed CEBAF Upgrade will

take advantage of recent advances in computing power, combined with a doubling of the existing energy of the electron beam (6 GeV), to create a 12 GeV electron beam capable of providing much more precise data on the structure of protons and neutrons. Specifically, the upgrade will enable scientists to address one of the great mysteries of modern physics – the mechanism that "confines" quarks together. New supercomputing studies indicate that force fields called "flux-tubes" may be responsible, and that exciting these "flux-tubes" should lead to the creation of never-before-seen particles.

This facility initiative is a result of almost ten years of scientific efforts and approximately a dozen community workshops. A pre-conceptual design already exists for the project (http://www.jlab.org/div_dept/physics_division/GeV.html). NSAC has recognized the scientific agenda to be compelling in its last two long range plans for nuclear science, culminating to the recommendation in the 2002 plan that the upgrade be completed "...as soon as possible." This initiative is included as a high priority in the Office of Science Facilities Plan, "Facilities for the Future: A Twenty Year Outlook"; upon Dr. Orbach's request, the project was reviewed by an Ad-hoc Facilities Subcommittee of the Nuclear Science Advisory Committee and given the highest available marks for science merit and technical readiness. The upgrade has the support of a large and active user community (~1200 scientists from 29 countries).

C. Importance of Mission Need and Impact If Not Approved

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 or more. Without this upgrade the scientific impact of continued operation of the Jefferson Laboratory facility would have to be evaluated in the context of the opportunities across the nuclear physics program.

The scope of the proposed project is the accelerator upgrade, a new experimental hall and associated beam-line, and upgrades to the existing three experimental halls. DOE intends to carry out a thorough review of the scientific priorities of the proposed upgrades of the existing halls while Jefferson Laboratory will in parallel explore other non-DOE/NP sources of support for the construction of this scientific equipment. A better understanding of non-DOE/NP funding contributions will be determined prior to CD-1.

D. Constraints and Assumptions

Operational Limitations

There are no foreseen operational limitations in regards to effectiveness, capacity, technology, or organization. The criteria for the operation of this type of facility are well established from years of experience in operating the current CEBAF accelerator at Jefferson Laboratory.

2 Geographic, Organizational, and Environmental Limitations

Jefferson Laboratory is located on 162 acres in Newport News, Virginia. Constructed over the period FY 1987-1995 for a cost of $513 million (Total Project Cost), TJNAF began operations in FY 1995 and is managed by the Southeastern Universities Research Association (SURA). Enhancing the capability of the machine in order to explore this new science is very cost effective; the upgrade can be realized for about 20% of the cost of the initial facility in "as spent" dollars. The percentage is significantly smaller if one compares the upgrade cost to the replacement cost of the facility, given both facility improvements over the past decade and inflation over that same period. There is no other facility in the world at which this project could be located. The Nuclear Physics program would either support this upgrade at the Jefferson Laboratory site, or not embark on this project.

3 Standardization and Standards Requirements

The 12 GeV Upgrade must conform to the applicable design and operational standards of the TJNAF CEBAF facility and conform to the project management guidance offered by the DOE M 413.3, *Project Management for the Acquisition of Capital Assets.*

4 Environmental, Safety and Health

DOE and Jefferson Laboratory will comply with the requirements of the National Environmental Policy Act (NEPA) and its implementing regulations (10 CFR 1021 and 40 CFR 1500-1508) prior to taking any action on the proposed project that could have adverse environmental effects or that would limit the choice of reasonable alternatives. The upgrade plan will utilize the existing tunnel and not change the basic layout of the accelerator. Three Environmental Assessments (EA) have been generated to date for Jefferson Laboratory (in 1987, 1997, 2002) and operations are currently approved to 8 GeV. The Jefferson Laboratory DOE Site Office anticipates that an additional EA addressing the 8 to 16 GeV beam energy range should be sufficient to satisfy the NEPA regulations.

5 Safeguards and Security

The CEBAF 12 GeV Upgrade activities will not change safeguards and security requirements at Jefferson Laboratory. The site is categorized as a low hazard non-nuclear facility. Currently the accelerator site is fenced and access is controlled primarily to ensure worker and public safety and for property protection. Normal safeguards and security requirements will be continued for the CEBAF 12 GeV Upgrade activities. None of the work at Jefferson Laboratory is classified.

6 Project Interfaces and Integration Requirements

An objective to this upgrade is to minimize the impact to the ongoing research program at Jefferson Laboratory. The majority of the work can be carried on in parallel to the current experimental program. The upgrade would only stop the program for one year, when the accelerator would be shut down, reconfigured, then recommissioned. It is believed that the construction of the new hall and upgrades to one of the existing experimental halls could be completed simultaneously with the completion of accelerator commissioning. The remaining two existing halls would not be completed until after accelerator commissioning.

The project will receive program guidance and funding from the Office of Nuclear Physics. An Integrated Project Team for the proposed project has been identified.

7 Affordability Limits on Investment

The estimated Total Project Cost of this construction project is 170 – 250 million dollars and included within the Office of Science *"Facilities for the Future: A Twenty Year Outlook"*. The FY 2005 OMB budget request includes R&D funds for this project. No PED funds are included in the FY 2005 OMB Target or Over Target request, pending S-1 approval of the *"Facilities for the Future: A Twenty Year Outlook."*

Subject to annual congressional appropriations, the construction of this facility would be accommodated within the NP budget. Additionally, as briefly discussed in Section C above, third party funding, such as funding from the state in which this facility is located, and other external funding options will be fully explored as part of the conceptual design effort.

8 Goals for Limitations on Recurring or Operating Costs

The cost for operating the upgraded CEBAF at 12 GeV will be included within the annual operating budget of the TJNAF CEBAF, which will be entirely funded by NP. The incremental operating cost of the upgraded facility is estimated to be approximately $15 million.

9. Legal and Regulatory Constraints or Requirements

The CEBAF 12 GeV Upgrade regulatory requirements will include typical construction permits. No significant hurdles are anticipated as the appropriate agencies are aware of plans for the project and the permit requirements will not be unique. A portion of the land required for construction of the new hall is currently owned by SURA. The deed for this land specifies that it must be used for future development of Jefferson Laboratory. Transfer of this land to DOE will be covered under the contractor contributions clause of the SURA contract.

10. Stakeholder Considerations

There are no significant stakeholder issues anticipated. The primary stakeholder in this project is the Jefferson Laboratory scientific user community of over 1,200 scientists. They have been extensively involved in the planning for the upgrade, and it is expected that the enhanced machine will continue to attract university, national lab and international users. This community leads the world in hadron physics and the upgrade is essential to maintaining this leadership. The National Science Foundation and foreign collaborators have made major investments in experimental equipment at the existing facility. Jefferson Laboratory also makes a major contribution to education at all levels. Approximately 150 Ph.D. degrees have been granted to date, based on work performed at TJNAF, with another ~ 125 in progress. The local community and Commonwealth of Virginia are strong supporters of Jefferson Laboratory and the CEBAF 12 GeV Upgrade. There are no existing or planned machines world-wide that can compete with the performance of either the existing machine or proposed upgrade.

Limitations Associated with Program Structure, Competition and Contracting, Streamlining, and Use of Development Prototypes or Demonstrations

The community of scientists and engineers who are capable of designing and building this energy upgrade at CEBAF is relatively modest in size. There are, however, adequate technical resources available at DOE laboratories, universities, and industry to plan and execute this project on a competitive basis. Much of the expertise required in designing and fabricating the superconducting radiofrequency (SRF) modules resides with the TJNAF staff, who are world leaders in SRF R&D technology.

The 12 GeV Upgrade project would make use of existing DOE contracts supplemented with competitive procurements as needed. The laboratory will be responsible for accomplishing the project under the terms of the operator's contract with the Department of Energy. Existing contracts with Jefferson Laboratory will support the Engineering Development needs of the upgrade. The project is planning to use fixed-price construction subcontracts and equipment procurements when possible. DOE Federal program managers will work closely with the Integrated Project Team and Jefferson Laboratory Federal Site Officers to monitor progress.

E. Applicable Conditions and Interfaces

TJNAF staff will play the lead in the upgrade of the facility, which aims to minimize the impact to the ongoing research program at Jefferson Laboratory. Communication between the laboratory and the user's group will be essential. Many universities and other laboratories have indicated interest in participating in the upgrade, particularly in scientific equipment. Financial contributions to the upgrade are anticipated by other domestic and foreign institutions. Effective management structures will need to be established for these efforts to facilitate participation and communication.

F. Resource Requirements and Schedule

The cost for the generation of the Conceptual Design Report (CDR) is ~ $1 million, in FY 2004; these funds would be re-directed from the planned funding support for TJNAF. A modest amount of R&D is necessary to complete the CDR. No new funds beyond the planned funding are needed in order to complete the CDR or R&D needed prior to CD-1; funds will be re-directed out of the FY 2004 NP budget. The preliminary estimated Total Project Cost (TPC) is $170-250 million in actual year dollars, including design, R&D, project management, quality assurance, contingency, installation and commissioning. There is a fairly large range in the preliminary estimated DOE Total Project Cost because the DOE scope has not yet been firmly established. Contributions from outside and foreign collaborators and other agencies should be well defined by CD-2, making the determination of a DOE baseline cost, schedule and scope possible. Jefferson Laboratory expects to redirect program funds towards the upgrade, which could have a substantial impact to the amount of needed new funds.

The following profile has been estimated for planning purposes and is accommodated within the Office of Science "*Facilities for the Future: A Twenty Year Outlook*". The FY 2005 OMB budget request includes R&D funds for this project. No PED funds are included in the FY 2005 OMB Target or Over Target request, pending S-1 approval of the *Facilities for the Future: A Twenty Year Outlook"* (dollar amounts are in actual year dollars and in thousands of dollars):

	CDR	R&D	PED	Long-Lead Time	Construction	Pre-ops
FY04	1, 000	500				
FY05		1,500	3,500			
FY06		3,000	15,000	19,000		
FY07		2,000	5,000		63,000	
FY08					70,000	
FY09					21,000	
FY10					1,000	12,000
FY11						8,000
FY12						
Total	**1,000**	**7,000**	**23,500**	**19,000**	**155,000**	**20,000**

Roughly 10% of the TPC is directed towards Project Engineering and Design (PED), which would start in FY 2005 at the level of $3.5 million. Project construction would then begin in FY 2007. Procurement of long lead-time items is in FY 2006, so a phased CD-2 and CD-3 is anticipated. The following preliminary milestone schedule could be considered:

CD-0 Approve Mission Need	Q4 2003
CD-1 Approve Preliminary Baseline Range	Q4 2004
CD-2A/CD-3A Performance Baseline and Construction of Long-Lead Time Items	Q1 2006
CD-2B Approve Performance Baseline Range	Q3 2006
CD-3B Approve Start of Construction	Q1 2007
CD-4 Approve Start of Operations	Q3 2011

G. Development Plan

Technologically, there are no constraints to the 12 GeV upgrade. The technical readiness of the project is high, as recently determined by the NSAC Facilities sub-committee. Only a relatively modest amount of R&D must be completed before a comprehensive conceptual design can be prepared. The technical risks are low and there are no operational constraints, and safety, health and environmental issues can be responsibly and economically handled based on years of experience operating Jefferson Laboratory.

A significant amount of pre-conceptual R&D has been accomplished to date, so the relative maturity of the project is advanced and pre-conceptual designs exist and have been reviewed by a peer of experts. Pre-conceptual R&D activities for the accelerator have concentrated on areas that would have high return in cost reductions for the accelerator upgrade, such as optimizing accelerator cavity performance to reduce the number of needed cryomodules and optimizing magnet performance to reduce the number of magnets to replace. Pre-conceptual R&D activities of the detectors have focused on magnet design and detector layout and simulated performance. R&D activities prior to CD-1 would focus on defining and prototyping an RF control system and the superconducting radio frequency accelerating cavity for the accelerator upgrade, and making technology choices and prototypes for detector elements and simulating magnet performances.

ESAAB Equivalent Board Meeting of the 12 GeV CEBAF Upgrade
January 15th, 2004

Recommendations
The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-0 "Approve Mission Need," for the 12 GeV CEBAF Upgrade as noted below.

1/15/04 Yes X No___
ESAAB Secretariat, Construction Mgmt. Support Division Date

1/15/04 Yes X No___
Representative, Non-Proponent SC Program Office Date

Yes___No___
Representative, Financial Mgmt. Division Date

1-15-04 Yes ✓ No___
Representative, Environment, Safety and Health Division Date

Yes ✓ No___
Representative, Security Mgmt. Team Date

Yes ✓ No___
Representative, Laboratory Infrastructure Division Date

Yes___No___
Representative, Grants and Contracts Division Date

Leonard Mucciarone 1/15/04 Yes ✓ No ___
Representative, Non-Proponent DOE Program Office Date

1/15/04 Yes ✓ No ___
Representative, Office of Engineering and Const. Mgmt. Date

Decision

Based on the information presented above and at this review, I concur with the recommendation to approve Mission Need (CD-0) of the 12 GeV CEBAF Upgrade. It is recommended that the Deputy Secretary approve the 12 GeV Upgrade Mission Need (CD-0).

Raymond L. Orbach Jan. 15, 2004
Raymond L. Orbach Date
Director of the Office of Science