September 2004

Critical Decision 3 Approve Start of Fabrication for the National Compact Stellarator Experiment Project At Princeton Plasma Physics Laboratory

Office of Fusion Energy Sciences, Office of Science

A. Purpose:

The purpose of this paper is to document the review by the Office of Science Energy Systems Acquisition Advisory Board-equivalent (ESAAB) for the Critical Decision 3 (CD-3) "Approve Start of Fabrication" for the National Compact Stellarator Experiment (NCSX) Project at Princeton Plasma Physics Laboratory (PPPL).

In May, 2001, the Acquisition Executive, Dr. N. Anne Davies, Associate Director of the Office of Fusion Energy Sciences (OFES), approved the "NCSX Mission Need Statement" as Critical Decision 0 (CD-0). The DOE identified a preliminary funding range of $69M +20% for the NCSX Project in its FY 2003 budget request to Congress.

In November, 2002, Dr. Davies approved the Preliminary Baseline Range (CD-1) for the NCSX Project at PPPL. The DOE also identified a preliminary funding range of $69M +20% for the NCSX Project in its FY 2004 budget request to Congress.

Following a Performance Baseline Review (PBR) by the Office of Science (SC-81) and an External Independent Review (EIR) by the Office of Engineering & Construction Management (ME-90), Dr. Davies approved CD-2 in February 2004 which established the Performance Baseline for the project at $86.3M with a completion date of May 2008.

B. Introduction to the NCSX Project:

The NCSX and the stellarator proof-of-principle program were proposed to DOE in May, 1998. A peer review panel and later the Fusion Energy Sciences Advisory Committee (FESAC) recommended development of the physics basis and pre-conceptual design for NCSX, which was done over the next few years. As the pre-conceptual design evolved, several implementation approaches for the core device were considered, ranging from a modest reconfiguration of the existing Princeton Beta Experiment -Modification (PBX- M) device to all-new fabrication. Trade studies examining a range of plasma configurations and coil topologies were conducted to support the decision process. Based on trade study results, PPPL selected fabricating a new device as the best approach. The main design features were established in a series of decisions in late 2000 and early 2001: the reference plasma configuration and its associated physics properties, modular coils for the main helical field magnets, and the size and performance parameters. The results of trade studies and alternative configurations support the conclusion that the best design approach for the mission was chosen. A second peer review, a Physics Validation Review in March 2001, confirmed the soundness of the NCSX physics design basis and the appropriateness of the implementation approach based on the pre-conceptual design. On that basis, the compact

stellarator was endorsed as a proof-of-principle concept by the FESAC, and the mission need CD-0 was approved by the DOE, OFES in May 2001. Following CD-0, minor adjustments were made to the scope, cost and schedule reflecting results of the conceptual design process and review, recent industrial manufacturing development studies, and programmatic adjustments in the funding profile.

Following CD-0 approval, the project began Conceptual Design activities, conducted a Conceptual Design Review, and achieved the CD-1 milestone in November, 2002. The lengthy Continuing Resolution in FY2003 delayed this “new start” project, and Title 1 design did not commence until April, 2003. Three major reviews, all of which are pre-requisites to CD-2, were completed in late 2003. These include the Preliminary Design Review, a performance baseline review conducted by the Office of Science Construction Management and Support Division, and an External Independent Review, conducted by the Office of Engineering and Construction Management (OECM). All three of these review committees enthusiastically endorsed the project as being ready for CD-2, which was approved in February, 2004, following agreement with the Director, Office of Science on final scope definition.

In preparation for CD-3, the project has conducted Final Design Reviews on the two most critical components, the Vacuum Vessel Subassembly (VVSA) and the Modular Coil Winding Forms (MCWF). The scope, schedule, and cost baselines proposed at this time reflect firm fixed-price cost proposals for these items as well as accumulated technical knowledge to date and the collective recommendations of technical review committees.

The project also conducted Independent Project Reviews in June and August, 2004, led by the Office of Science, Construction Management and Support Division, which endorsed the project’s readiness for CD-3. The Integrated Project Team is confident that the project can be successfully completed within the established baseline parameters. The implementation of the comments received from all recent project reviews confirms the adequacy of the project Total Estimated Cost (TEC) of $86.3M.

C. Mission Need and Justification:

Fusion is the power source of the sun and the stars. The sun and stars are comprised of a special state of matter called "plasma." In this plasma, hydrogen nuclei combine, or "fuse," to form nuclei of a heavier element, helium. In the process of fusing, some of the mass involved is converted directly into large amounts of energy. Fusion researchers seek to harness this energy for applications such as central station electrical generation. The mission of the U.S. Fusion Energy Sciences Program is to "advance plasma science, fusion science, and fusion technology -the knowledge base needed for an economically and environmentally attractive fusion energy source."

NCSX is an integral part of the Department's Office of Fusion Energy Sciences program and provides a unique opportunity to advance its mission. The mission of the NCSX is to acquire the physics knowledge needed to evaluate compact stellarators as a fusion concept, and to advance the physics understanding of three-dimensional plasmas for fusion and basic science. This mission of the NCSX supports two of the Fusion Energy Sciences program's goals (Report of the Integrated Program Planning Activity, December, 2000), namely:

1. Resolve outstanding scientific issues and establish reduced-cost paths to more attractive fusion energy systems by investigating a broad range of innovative magnetic confinement configurations.

2. Advance understanding of plasma, the fourth state of matter, and enhance predictive capabilities through comparison of well-diagnosed experiments, theory, and simulation.

D. Final Design Report:

A Final Design Report (FDR) is required for CD-3 approval. A FDR for critical project components (VVSA & MCWF) was prepared for review in FY2004, and a successful review was conducted in May 2004. The Review Committee report and recommendations were received by the Integrated Project Team in June, 2004. A disposition report which addresses all of the recommendations of the committee is available, and the Integrated Project Team reviews it regularly.

E. Project Execution Plan:

A current Project Execution Plan (PEP) is a prerequisite for the CD-3 approval. The approved PEP has been reviewed for accuracy and is posted on the project website.

F. Project Scope Baseline:

The scope of the NCSX Project consists of the design, fabrication, assembly, and initial startup of the NCSX device. The PEP contains a more detailed technical scope definition and description of the project. Successful completion of project scope is defined by production of a "first plasma" with coils at cryogenic temperatures as defined in the PEP. E-beam mapping to characterize the magnetic surfaces is also included in the baseline scope. The recommendations of all review committees have been factored into the current project baseline scope.

G. Project Cost and Schedule Baseline & Resource Loaded Schedule:

The NCSX Project is classified as a Major Item of Equipment (MIE) and is funded with Capital Equipment funds. The current Total Estimated Cost (TEC) funding plan is shown in the following table:

TEC—Fiscal Year Resource Plan

FY	2003	2004	2005	2006	2007	2008	TOTAL
	$7.9M	$15.9M	$15.9M	$22.1M	$19.4M	$5.1M	$86.3M

The TEC, broken down by Work Breakdown Structure (WBS) categories, is shown in the table below:

WBS Item #		
1	Stellarator Core	$49.4M
2	Auxiliary Systems	$ 0.8M
3	Diagnostic Systems `	$ 1.2M
4	Electrical Power Systems	$ 3.7M
5	Central I & C Systems	$ 2.2M
6	Facility Systems	$ 1.1M
7	Test Cell Prep & Machine Assembly	$ 4.3M
8	Project Management & Integration	$10.2M
Total costs		$72.9M
Contingency		$13.4M
Total Estimated Cost		$86.3M

The proposed top level schedule baseline is as follows:

CD-0 Approve Mission Need	May 2001
CD-1 Approve Preliminary Baseline Range	November 2002
CD-2 Approve Performance Baseline	February 2004
CD-3 Approve Start of Fabrication	September 2004
CD-4 Approve Transition to Operations	May 2008

H. Acquisition Execution Plan:

An Acquisition Execution Plan (AEP) was required prior to CD-2 approval. The acquisition strategy in this document is still valid, and therefore revision to the AEP will not be made at this time. Changes in scope, schedule, and cost baselines that have occurred since the AEP was approved are captured in the current version of the PEP. The document has been finalized, reviewed by OECM as required, concurred in by OFES, and approved by the Under Secretary of Energy, Science and Environment.

The NCSX is being designed and fabricated at PPPL, which has lead responsibility for execution of the NCSX Project. The Oak Ridge National Laboratory (ORNL), as a partner to PPPL**,** provides major support, including leadership in specific areas. Combining the PPPL and ORNL team is advantageous as both laboratories have extensive experience in the design and fabrication of stellarators and other fusion confinement experiments.

While the NCSX Project consists of an integrated team of both PPPL and ORNL personnel, imposing a single point of contact for major procurements offers significant advantages. Assigning the major procurements to PPPL will streamline the procurement process by utilizing the same procurement personnel to conduct all procurements regardless of whether designed by PPPL or ORNL.

Commercial and best business practices will be used to accomplish all procurements. Many of the equipment procurements will use commercial or best value source selection concepts

allowing cost and technical trade-offs to ensure the best value is obtained in acquiring components. Fixed price contracts are contemplated for all production procurements. As part of the phased acquisition strategy, industry has had early involvement in developing viable manufacturing solutions, which should facilitate the use of fixed price contracts for the production phase.

The NCSX Project has committed to a high degree of supplier input and participation in the development of requirements for major systems, while at the same time maintaining appropriate in-house control and responsibility for definition, design and integration of these items.

The majority of the subcontracted work to be performed for NCSX consists of hardware fabrication. The major stellarator core components to be specially fabricated for NCSX will be the subject of a multi-stage development program that will yield designs that permit fabrication under fixed-price "build-to-print" subcontracts. Depending on schedule considerations, it may be appropriate to use one or more fixed-price incentive subcontracts, with negotiated targets based on delivery or cost. These performance based subcontractor incentives will be considered by the Project if such incentives appear necessary or appear to offer appropriate cost, schedule, or technical advantages to the Project. For the ancillary systems components, it is anticipated that the majority are readily available off-the-shelf.

The Project will attempt to promote and maintain the cost-reduction effects of competition throughout all phases of acquisition, including the acquisition of major components. As described above, the procurement of those components that pose the highest degree of manufacturing risk will be developed through a series of manufacturing studies, a prototype fabrication and finally, a production fabrication subcontract. Currently, the project has negotiated firm fixed price proposals for these critical components (VVSA & MCWF), and is ready to award. Off-the-shelf hardware will be purchased through the PPPL procurement system, using a variety of appropriate, competitively-awarded purchasing vehicles, including subcontracts, purchase orders and blanket purchase agreements.

I. Environmental Strategy:

In compliance with the National Environmental Policy Act (NEPA), the Chicago Operations Office (CH) has performed a NEPA Guidance Review. The results of the review are that: the environmental hazards associated with the NCSX Project appear to be well within range of those currently existing for similar fusion experiments at PPPL. Consequently, a Finding of No Significant Impact (FONSI) was signed in December, 2002.

J. Integrated Safety Management & Preliminary Hazard Analysis Report:

A preliminary Hazard Analysis Report was completed as a prerequisite for the CD-2 approval. The NCSX Project's Environmental Evaluation Notification Form (EENF) report documents the safety analysis of the NCSX Project design and operation. The report's purpose is to identify hazards associated with the design and operation of the NCSX Project; assess risk; and establish engineering and administrative controls needed to eliminate or reduce the associated risk to acceptable levels. Specific ES&H hazards and the means for

their mitigation have been detailed, and will be managed through the PPPL Integrated Safety Management (ISM) Program.

K. Integrated Safeguards & Security Management

NCSX is located in an existing building within the confines of PPPL's C-site. Thus it is governed by existing lab-wide security standards based on threat risk assessment. Line management is accountable for associated security systems including physical access controls (ACAMS), operational interlock systems, cyber security controls, foreign visits and assignments, and centralized material controls.

L. Project Controls & Earned Value Management System:

An Independent Review of the NCSX Project Control System was conducted in February, 2003. The review committee found that the system was in full conformance with accepted industry standards. Monthly Earned Value reporting has commenced with the establishment of the Performance Baseline at CD-2, and the project is currently performing within acceptable ranges. The project Baseline Change Control System is functioning appropriately and all records are available on the project website.

M. CD-3 Pre-requisites:

All CD-3 related information is available at http://ncsx.pppl.gov//Meetings/CD_3/CD_3.html for ESAAB committee review:

September, 2004

NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

CD-3 REQUEST

Submitted by:

_____ Date:_____
Gregory E. Pitonak
NCSX Federal Project Director
Princeton Site Office

_____ Date: _____
Jerry Wm. Faul
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_____ Date: _____
Gene R. Nardella
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September, 2004

NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

CD-3 REQUEST

Recommendations:

The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-3, Approve Start of Fabrication for the National Compact Stellarator Experiment Project at PPPL as noted below:

_____ Yes ___ No ___
ESAAB Secretariat, Construction Management and Support Division/Date

_____ Yes ___ No ___
Representative, Non-Proponent SC Program Office/Date

_____ Yes ___ No ___
Representative, Environmental Safety and Health Division/Date

_____ Yes ___ No ___
Representative, Financial Management Division/Date

_____ Yes ___ No ___
Representative, Security Management Team/Date

_____ Yes___ No___
Representative, Office of Engineering & Construction Mgmt/Date

_____ Yes ___ No ___
Representative, Grants & Contracts Division/Date

_____ Yes ___ No ___
Representative, Laboratory Infrastructure Division/Date

Approval:

Based on the material presented above and this review, Critical Decision 3, Approve Start of Fabrication, is approved. Therefore, the Princeton Site Office is authorized to continue with expenditure of Major Item of Equipment funds for the National Compact Stellarator Experiment Project.

_____ _____
Dr. N. Anne Davies DATE
Associate Director
Office of Fusion Energy Sciences
Office of Science