Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

National Spherical Torus Experiment (NSTX) Upgrade

August 2010

EXECUTIVE SUMMARY

As requested by Dr. Edmond Synakowski, the Associate Director for Fusion Energy Sciences (FES), Office of Science (SC), a Department of Energy (DOE) Independent Project Review of the National Spherical Torus Experiment (NSTX) Upgrade was performed at Princeton Plasma Physics Laboratory (PPPL) on August 10-11, 2010. The purpose of the review was to assess the project's readiness for Critical Decision (CD) 2, Approve Performance Baseline and CD-3a, Initiate Early Procurement Construction of a Limited Number of Work Packages.

The NSTX Upgrade project scope consists of the design, fabrication, and installation of a new Center Stack and the refurbishment and installation of a second Neutral Beamline on the existing NSTX reactor. The upgrade will allow more knowledge and understanding on the next-step spherical torus configuration, and access to high normalized plasma pressure at high plasma temperature, thereby greatly expanding the understanding of fusion plasmas.

Technically, the project requirements and design are sufficiently mature for CD-2. CD-3a will be ready for approval after completion of the appropriate design and analysis activities. Compared to previous actual costs for similar projects on NSTX beamline one and other facilities (e.g., the General Atomic DIII-D machine), projected costs associated with neutral beam activities appear high. Most ancillary systems are very similar to existing systems for NSTX, and the design and cost estimates are well-developed with a sound basis.

The project presented a Total Project Cost (TPC) of $90.5 million (including $16.7 million in contingency, $11.5 million of cost already spent, and $62.3 million of base cost). The project completion is estimated at March 2015, which includes approximately eight months (or approximately 17 percent) of schedule contingency. According to the Committee, the base cost estimate appeared to be high and the cost and schedule contingency appears optimistic. The basis for this statement includes the following:

- Cost is dominated by internal PPPL management, engineering, and technical staff resources.
- The project has performed a comparison of the Neutral Beam (NB) costs, and the proposed cost for the second NB is very generous.
- The project has not performed a cost comparison, at a parametric level, of the NSTX Upgrade project with other fusion machines to determine reasonableness of the cost.

- The cost contingency is back-end loaded.

- The schedule contingency of eight months appears low.

The project team is properly organized and experienced in the major areas associated with the project. With the exception of the Hazard Analysis Report, all project documents are complete and ready for CD-2/3a approval after incorporation of the Committee's comments.

Environmental, Safety and Health aspects are being properly addressed. However, PPPL and DOE should determine and agree upon an authorization basis and readiness review pathway and then complete the Hazards Analysis. Independent reviews have been performed; however, these reviews did not focus on cost details as much as technical details. Rationale for long-lead procurements appear sound and should significantly reduce schedule risk.

Based on the information the NSTX project presented, the Committee's major recommendations to the project include the following:

- Convene an external peer committee to review verification of key aspects of the design and analysis.

- Prior to CD-2:

  - Perform focused cost reviews of the major cost drivers and re-assess the cost and schedule estimate and contingency.
  - Re-evaluate the annual allocation of cost contingency.
  - Issue an updated Hazard Analysis Report
  - Develop a process to approve long-lead procurements and early start activities.

- After CD-2, conduct periodic PPPL project peer reviews.

- Approve CD-3a after completion of the appropriate design and analysis activities.

CONTENTS

1. INTRODUCTION

The mission of the National Spherical Torus Experiment (NSTX) program is to explore the properties of compact and highly normalized pressure ‘spherical torus’ (ST) magnetic fusion plasmas. The compact and accessible ST configuration is potentially advantageous for the development of fusion energy and also broadens and improves the scientific understanding of plasma confinement in the ITER project. The plasma confinement capability, and the achievable plasma temperature, scale strongly with plasma current in the tokamak and ST. Plasma current in the range of 1 MA (million amperes or 1 mega-ampere) is required to access plasma temperatures needed to understand ST physics under fusion-relevant conditions. The only existing Department of Energy (DOE) facility capable of producing mega-ampere-class ST plasmas is the NSTX facility.

The ST shares many features with the conventional tokamak, but several important differences have also been identified—for example the scaling of turbulent energy transport with the frequency of inter-particle collisions. Understanding the causes of these differences is important not only to ST research, but also for developing a predictive capability for magnetic confinement generally. The new Center Stack would double the NSTX toroidal magnetic field to 1 Tesla and enable a doubling of the maximum plasma current to 2 MA for the first time in STs. The Center Stack Upgrade (CSU) combined with the installation of a second Neutral Beam Injection (NBI) will enable operation at higher magnetic field, current, and plasma temperature, thereby reducing the plasma collisionality to values substantially closer to those projected for next-step ST facilities and for ITER. Access to reduced collisionality will extend the plasma physics understanding of the ST and aid in the development of predictive capability for plasma confinement. Further, controllable fully-non-inductive current-sustainment is predicted to be provided by the second NBI, and would enable tests of the potential for steady-state ST operation and contribute to assessing the ST as a cost-effective path to fusion energy.

The ST is particularly well-suited to provide a cost effective test-bed to bridge several gaps from successful ITER operations to a demonstration fusion power plant (Demo) as identified in the Fusion Energy Sciences Advisory Committee (FESAC) report issued October 2007, and entitled, “Priorities, Gaps and Opportunities: Towards A Long-Range Strategic Plan for Magnetic Fusion Energy”. More recently, in November 2008, the “Report of the FESAC Toroidal Alternates Panel” also found that the ST offers the potential for an attractive test facility for developing fusion components. Upgrading the NSTX facility could significantly narrow or close capability gaps identified above. In support of these upgrades, the NSTX collaborative research team developed its Five-Year Program Plan for 2009-2013, which was favorably peer reviewed and strongly endorsed in DOE/Fusion Energy Sciences (FES) reviews conducted on July 28-31, 2008. The review panel specifically endorsed NSTX Upgrade plans, which form the central elements of the NSTX Five-Year Program Plan.

2. TECHNICAL STATUS

2.1 Magnets and Core

2.1.1 Findings

In addition to the charge questions, the review of the magnets and core resulted in several findings.

The CSU task includes a new, larger diameter Center Stack with new ohmic heating (OH) coils, additional poloidal field (PF) coils, new plasma facing components (PFCs), new toroidal field (TF) joint design and structural reinforcement for the TF and PF coils.

Significant electromagnetic, thermal, and mechanical analyses have been performed to evaluate design options, with ‘overlapping results’ used as one method for verification of the analysis. There has been no independent, external verification.

The project convened an external preliminary design review in June. The review committee provided a positive technical review with some recommendations. The project is in the process of evaluating the recommendations and has already accepted some of them, such as adding a centering feature between the OH and TF bundle and looking for alternative suppliers for the TF copper extrusions.

Critical R&D is still ongoing. A special primer is being tested to improve shear bond strength of the epoxy glass insulation to the TF copper and the feasibility of a friction stir welded joint between two different copper alloys on the TF inner leg is being confirmed.

The coil support structure is designed for a ten percent margin above the defined operating scenarios. A Digital Coil Protection System (DCPS) is required to protect the machine from potentially destructive loads.

Cost estimates are documented in Work Authorization Forms. The estimates examined appeared to be adequate for the planned work and had significant contingency.

2.1.2 Comments

Several additional observations were made during the review with respect to the magnets and core.

The upgrade design requires a multitude of mechanically bolted high current carrying electrical connections. The desired outcome for such a connection is a low-resistance joint that is operationally stable over time. The upgrade joint design is superior to the old design, but there is no plan to do electrical testing of a prototype joint. The ST group has stated that they are planning on regular maintenance inspection of these electrical joints during down times and to possibly re-torque the bolted joints. The Committee suggested that there needs to be an active feedback system of voltage taps across all of these joints to monitor the change in resistance over time. This will allow the group to react to sudden or long-term changes in joint condition and only disturb those joints that require rework. It may be prudent to retain some or all of the voltage tap instrumentation that is used now.

Some deflection instrumentation exists on the present machine, so this should be transferred to the upgraded machine to verify that the structure is behaving as predicted.

The shear stress in the TF bundle insulation is fairly high, and the project has selected a special primer to improve the shear capability of the epoxy to copper bond. Since the TF bundle is fabricated in four quadrants that are subsequently joined by VPI, it may be worthwhile to test the shear strength of the quadrant-to-quadrant joint also. It may be prudent to test the effects of the multiple Vacuum Pressure Impregnation (VPI) cure cycles (quadrant, full TF stack, OH).

The shear stiffness of the quadrant-to-quadrant joint will be different since the bond line is more than twice as thick as the other turn-to-turn bonds. It may be worth including this stiffness difference in the analysis to see if it has any effect.

The PFC tile design is an improvement of the existing design and is well thought out, but some material characterization, prototyping, and mechanical testing has yet to be completed. A new design scheme for mounting the plasma facing components to the Center Stack casing has been developed for the mechanical mounting and tile material. Early procurement of the tiles is requested as a long-lead procurement. The Committee was concerned about the female nuts that will be welded to the casing that will act as multiple virtual vacuum leaks within the vessel from trapped air volume in the nuts. The Committee is also concerned about the torque limitation at the nut weld joint to the casing. Further prototyping and studies are required to better understand the mechanical design limitation of the fastening scheme and load limitations of the Carbon Fiber Composite (CFC) tile material.

The Failure Modes and Effects Analysis (FMEA) has been updated.

2.1.3 Recommendations

1. Convene external peer reviews/verification of key aspects of the design and analysis, especially the TF joint electrical design and the algorithms to be used for the digital coil protection system, prior to the Final Design Review (FDR).

2. Develop a plan for operating instrumentation to monitor selected displacements, temperatures and joint resistance, prior to the FDR.

3. Refrain from placing contracts for the conductor until after the stir welding processes evaluation has been satisfactorily completed and found to meet mechanical and electrical requirements for the joint design.

4. Refrain from placing contracts for the PFC tiles until after the prototyping of the tiles and mechanical testing of the fastening scheme is completed.

2.2 Neutral Beams

2.2.1 Findings

The proposed NSTX neutral beam upgrade includes decontamination of a Tokamak Fusion Test Reactor (TFTR) beamline and three ion sources, the subsequent installation of these systems along with all the neutral beam support systems, and the necessary vessel modifications. Services (water, power, cryogenics) for this new beamline cannot use the existing services for the first beamline in the machine hall and therefore will require significant new infrastructure. In addition, significant existing equipment in the machine hall will need to be removed for installation of the beam and subsequently reinstalled.

Decontamination of three ion sources and beamline is underway and significant reductions in contamination have been achieved. A peer review of the progress held in April 2010 concluded that the decontamination was essentially done and that the beamline can be used on NSTX with minimal impact to physics operations.

Installation and operation of the second beamline will follow, for the most part, the process of installation and operation of the original beamline, which has been in use for almost a decade on NSTX. Because of the success in installing and commissioning the original beamline, there is a high probability that the new beamline will operate as desired and meet the established performance requirements (5MW for 5 s and 9 MW for 1 s).

The main technical concern of the Committee was related to potential distortion of the vacuum vessel during both cutting of the vessel wall and subsequent welding of the port attachment. The Committee noted that several steps have been taken to mitigate these risks including installing a temporary bracing structure on the inside of the vessel to provide additional strength and improvements in the vessel cutting process using a plasma cutting technique.

Overall, the projected cost of this activity is significantly higher than a similar activity for the original NSTX beamline. This increase is due to the increased scope of the present activity, tritium decontamination, and management costs.

2.2.2 Comments

The plan presented by the NSTX upgrade team on the Neutral Beam upgrade was clear, technically sound, and well advanced at this stage in the design process. The Committee noted that the extent of planned work is that of essentially a brand new beamline except for the beam itself. Services, interfaces, and controls are for the most part brand new.

The only remaining technical concern is the integrity of the vacuum vessel when performing the necessary modifications for the new port for the neutral beam. Confidence in maintaining the integrity has been increased significantly with the addition of the temporary bracing structure. The Committee also noted the improved prospects of making the cut on the vacuum vessel without creating a large amount of heat in the vessel wall by using plasma cutting. The plan presented for installation of the new beamline did not include a test of the vacuum integrity of the port interface weld until after machine pump-down, introducing a significant risk at a late stage in the project.

After lengthy discussions with the staff with regard to cost estimates, it is clear that the staff is confident in their projections of the cost to complete this project. However, the projected costs seem high when compared with previous actual costs for similar projects on NSTX (original beamline, approximately $6 million FY 2000) and other facilities (e.g., DIII-D, approximately $6 million FY 2005).

The Committee noted that the current management plan for this project involves individuals whose responsibilities are split between NSTX operations and the upgrade project during the year leading up to the outage. Due to the critical nature of project planning in the time leading up to project initiation, this is a concern.

2.2.3 Recommendations

5. Re-evaluate the costs of this portion of the project, possibly with an independent review.

6. Make a mock-up of the vessel wall and perform test cuts to mitigate uncertainties.

7. Perform analytical calculations on the vessel structural response to the planned cuts and welds in vessel wall.

8. Include in the plan a leak check of vacuum weld after the new port box is welded in place.

2.3 Ancillary

2.3.1 Findings

Top level requirements for all WBS subsystems are given in the General Design Requirements document. Work Authorization Forms (WAF) have been developed to define the tasks and develop the material and manpower estimates. A Risk Registry is kept but few have been identified for these systems.

Preliminary designs have been developed for the systems that are generally modifications or similar to existing NSTX systems.

Power supply upgrades will use TFTR equipment and a general assessment has indicated the units should be acceptable. Four spare TFTR rectifiers are available if needed.

A DCPS will be used to prevent structural damage due to incorrect or excessive coil current combinations.

2.3.2 Comments

Several observations were made during the review with respect to the Ancillary Systems.

Most Ancillary systems (Vacuum pumping, Water Cooling, Bake Out, Gas Delivery, Power Supplies, and Installation and Commissioning) are very similar to existing systems for NSTX and the design and cost estimates are well-developed with a good basis.

System Design Requirement documents are being developed and are planned to be completed prior to the FDR.

A new element is the incorporation of the Digital Coil Protection (DCP), which will require software development to ensure that the structure is protected for a large variety of coil current and plasma current combinations.

The DCP is to be designed for high reliability: failure probability per year
10-4< Pf <10-6.

2.3.3 Recommendation

9. Conduct a design review of the Digital Coil Protection system with external reviewers to include consideration of the coil current combinations, analysis of the loads and overall system design including software and reliability requirements for all components and instrumentation prior to the Final Design Review in 2011.

3. COST ESTIMATE

3.1 Findings

The NSTX Upgrade is a Major Item of Equipment project with a Total Projected Cost (TPC) estimated at $90.5 million (that includes approximately $16.7 million in contingency or 26 percent on the estimate-to-complete).

PROJECT STATUS (As of May 1, 2010)		
Project Type	MIE	
CD-1	Planned: January 2010	Actual: April 2010
CD-2	Planned: October 2010	Actual:
CD-3	Planned: July 2011	Actual:
CD-4	Planned: March 2015	Actual:
TPC Percent Complete	Planned: N/A%	Actual: 14%
TPC Cost to Date	$11.5M	
TPC Committed to Date		
TPC	$90.5M	
TEC	$79.5M	
Contingency Cost (w/Mgmt Reserve)	$16.7 M	26% to go
Contingency Schedule	8 months	17%
CPI Cumulative	N/A	
SPI Cumulative	N/A	

The project consists of two main subprojects including the CSU and installation of refurbished second NB. PPPL has experience with similar projects, reducing the risk of cost and schedule unknowns. The project is scheduled for completion in March 2015, with approximately eight months or 17 percent of schedule contingency. All eight months of schedule contingency are fully funded. The project has spent approximately $11.5 million to date. These cost and schedule estimates are based on the funding profile shown in Table 3-1. The NSTX Upgrade funding is from the NSTX program funds and is consistent with FES funding guidance.

Table 3-1. NSTX Upgrade Cost and Schedule Estimates

	Prior Year	FY 10	FY 11	FY 12	FY 13	FY 14	Total ($M)
Base Estimate	$5.1	$9.0	$7.9	$12.8	$21.9	$17.2	$73.8
Contingency			$1.2	$1.9	$3.4	$10.2	$16.7
Total ($M)	**$5.1**	**$9.0**	**$9.0**	**$14.6**	**$25.3**	**$27.4**	**$90.5**

Both the cost and schedule estimates were developed based on estimates of activity durations and resource requirements provided by the Job Managers. The basis of estimate breakdown consists of 50 percent actual experience, 40 percent engineering judgment, 7 percent vendor quotes, and 3 percent other. The cost is categorized into 49 percent fabrication/ installation, 23 percent design, 19 percent procurement, and 9 percent in project management.

The project has developed a resource loaded schedule, including a critical path. The current critical path includes the OH coil design and fabrication, CS fabrication activities, and integrated system testing.

As part of the CD-3a request, the project is proposing to purchase long-lead items with a total cost of $1.442 million including:

- Inner Torroidal Field (TF) Bundle - Manufacture Inner TF Copper extrusions;
- Inner TF Bundle - Machine Inner TF conductors [grooves, lead area];
- OH Coil - Manufacture OH Copper conductor [extrusion]; and
- Inner TF Bundle - Friction Stir-Weld coil lead conductors.

The project is also proposing approximately $410K in facility upgrades as part of CD-3a to support CS fabrication.

Risks have been identified, mitigation strategies considered, and cost/schedule impacts quantified in the risk registry. Project risks are reviewed and updated monthly.

The project's 'standing army' cost is approximately $282K per month, needed for management, health physics support, and allocations.

The project has been using an Earned Value Management System (EVMS) on the project since December 2010. The project has developed required documents needed for CD-2 approval including the preliminary Project Execution Plan (PEP), Acquisition Strategy, and conceptual design report (CDR).

3.2 Comments

At this stage of the project, the proposed cost estimate including contingency does not appear ready to baseline, specifically:

- The proposed base cost estimate appears high and both the schedule and cost contingency amounts appear optimistic.

- The project has performed a cost comparison of the NB costs, the proposed cost for the second NB is very generous.

- The project has not performed a cost comparison, at a parametric level, of the NSTX Upgrade project with other fusion machines to determine reasonableness of the project cost.

- The cost contingency is back-end loaded based on the current work planning with over 5 percent included in the final year of the project. PPPL stated that work could be re-sequenced to free-up cost contingency if needed.

- The schedule contingency of eight months appears low when considering the unique nature of the proposed work and the specialized expertise required.

The Committee judged that PPPL should reassess the cost and schedule estimate and contingency and reevaluate the distribution of contingency to determine if additional contingency can be applied earlier in the project.

There are minor updates needed on project documentation prior to CD-2 approval.

The risk registry has been developed. However, the document should be updated to reflect more descriptive risk description and more clearly stated risk mitigation approach.

The project has planned for execution of long-lead procurement of approximately $2 million. These procurements are relatively low-risk activities to be completed prior to design completion and appear appropriate at this stage of the project.

3.3 Recommendations

10. Prior to CD-2, reassess the cost and schedule estimate and contingency.

11. Prior to CD-2, re-evaluate the annual allocation of cost contingency.

12. Prior to CD-2, update the risk registry.

13. Approve CD-3a after completion of the appropriate design and analysis activities.

4. ENVIRONMENT, SAFETY and HEALTH

4.1 Findings and Comments

The facility as observed has adequate security for objects of theft such as activated copper. PPPL has procedures for welding non-stamped vessels. PPPL Engineering Standards reference similar codes to those found in 10CFR851, but not all codes that are found in 10CFR851.

Some controlled documents for essential design functions date back past a three-year period; for example, PPPL Electrical Construction Specification ES-ELEC-004 is dated December 17, 2004. Not all managers, when questioned, were aware of Conduct of Operations requirements.

Integrated Safety Management (ISM) principles and good safety culture were professed by managers. PPPL has a Job Hazard Analysis process, ESH-400. PPPL performs an independent Quality Assurance (QA) check on closeout of chits. PPPL has training matrices for staff.

PPPL obtained National Environmental Policy Act (NEPA) Categorical Exclusion for the NSTX Upgrade on March 27, 2009.

A Preliminary Hazards Analysis (PHA) report for NSTX Upgrade was prepared and dated July 8, 2009. It is a list of expected hazards. It is not a Hazards Analysis (HA) as defined by DOE Orders.

NSTX may be a former nuclear facility (radiological facility) based on NSTX being within the fenced boundary of the former TFTR. Thus, nuclear terminology, nuclear definitions and nuclear type assessments may be applicable to NSTX such as PHA and HA.

DOE-STD-6003-96, Safety of Magnetic Fusion Facilities: Guidance also defines an HA apart from nuclear orders.

Radiological hazards due to the NSTX Upgrade can be extrapolated from past NSTX operations and measurements, and information in the NSTX Safety Analysis Document (SAD) Revision 5, dated November 2001.

The 2001 NSTX SAD does not address potential oxygen deficiency hazards (ODH) from cryogenic liquids.

The proposed NSTX Upgrade is not included in the 2001 NSTX SAD at this time. Laser hazards and ODH were not listed in the PHA for the NSTX Upgrade project.

Applying 10CFR851 safety requirements to the vacuum vessel due to modifications that may contribute to buckling and due to potential for the vacuum vessel to be backfill pressurized were not done.

DOE Order 413.3a requires an HA that updates the PHA for CD-2. If the NSTX facility is a “Less Than Category 3 Nuclear Facility,” then the requirements for an HA may be found in DOE-STD-1189-2008, Integration of Safety into the Design Process. If the NSTX facility is a fusion facility, then the guidance for the HA may be found in DOE-STD-6003-96, Safety of Magnetic Fusion Facilities: Guidance. Neither type of HA was presented.

NSTX is a low-energy accelerator-collider, where accelerated ions collide together in a high magnetic field. It technically meets the criteria of an Accelerator Facility, and has identical properties and hazards (radio frequency, Lasers, cryogenics, accelerated ion beams, direct radiation, activation, confined space, high magnetic fields, potential ODH, electrical hazards, and mechanical hazards). Accelerators and accelerator-colliders follow DOE Order 420.2B, Safety of Accelerator Facilities, for authorization basis documents and readiness review. Accelerators are exempt by law from 10CFR830.

NSTX has no criticality hazard and therefore does not meet the definition of a reactor or sub-critical assembly. NSTX does not involve radioactive and/or fissionable materials in such form and quantity that a nuclear or a nuclear explosive hazard potentially exists to workers, the public, or the environment and is therefore not a non-reactor nuclear facility.

This year, C-AD, a high-energy accelerator-collider, built an electron-beam ion source (EBIS) capable of injecting all ion species into a vacuum, ions from z=1 to z=105. EBIS is modern technology and cost $19.4 million, which included a building, an additional 2 MeV Linac and a beam transport line. It is not clear rather it would be economical to resurrect an ion source that was built to accelerate and inject tritium at a former Category 3 nuclear facility (TFTR) and then install it at NSTX, especially since NSTX is accelerating and injecting deuterium, which is not radioactive like tritium.

4.2 Recommendations

14. Ensure contract rules (e.g., Conduct of Operations, 10CFR851) are addressed in the PPPL design review process, PPPL controlled documents, training and practices.

15. PPPL and DOE should determine and agree upon the set authorization basis documents and readiness review pathway to be used for the NSTX Upgrade project and then complete the Hazards Analysis as required in DOE Order 413.3A for CD-2.

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5. MANAGEMENT

5.1 Findings

Since the December 2009 DOE/SC review, the NSTX Upgrade project and Princeton University have chartered and conducted a series of independent reviews and advisory meetings. A preliminary design review of the integrated project was held as the final step in preparing for CD-2. PPPL is in the process of forming a project management advisory committee, which will meet for the first time within a few months.

The proposed baseline project plan uses a funding profile that is consistent with FES guidance. Cost contingency is back-loaded with over half included in the final year of project funding. The plan includes a total contingency of 26 percent of the cost to go, and has a minimum schedule contingency of eight months between its scheduled early finish date and CD-4 completion milestone. The project is requesting approval to proceed with procuring several long-lead items along with authorization to begin early project work before CD-3 approval.

The project has continued with R&D activities and utilized mockups to verify assembly of more complicated sub-assemblies to reduce risk and establish process parameters. PPPL leadership is confident that the project is a low technical risk and has high overall confidence in the proposed baseline. The estimated cost is dominated by internal PPPL management, engineering, and technical staff resources.

All documentation required for approval of CD-2 is either already completed and approved or ready for sign-off (except the HA). The PEP is mostly complete and almost ready for program review. Three key assumptions identified in the draft PEP related to schedule and funding are not identified in the risk registry.

5.2 Comments

The NSTX Upgrade project management team is experienced and very familiar with the major components associated with the project. There is minimal R&D needed to complete the project, and it is focused on construction or fabrication process finalization.

Cost contingency and schedule contingency appear low and cost contingency is too back-loaded in the profile. The Committee was pleased to see that the project team had already responded to this comment with a draft revision that spreads contingency more evenly through time. The independent reviews held to date have not focused on cost details as much as technical details. To improve confidence in the cost baseline, PPPL should conduct focused cost reviews using external experts for the project's major cost drivers.

In reviewing the NSTX Upgrade project PEP, the Committee concluded that it has too many details to define project completion and too many Level 2 milestones. The Committee also suggested eliminating the Management Reserve section.

The project's rationale for long-lead procurements appears sound and should significantly reduce schedule risk.

The proposed project management advisory committee that would report to the PPPL director is an excellent idea. The project and PPPL should continue to look for more opportunities to engage outside management and engineering expertise.

5.3 Recommendations

Prior to CD-2 approval:

16. Revise PEP to clearly define project completion criteria and delete unnecessary details.

17. Issue Hazard Analysis Report.

18. Reevaluate cost contingency and schedule contingency.

19. Consider revising the budget profile to spread more contingency to the early years.

20. Perform focused cost reviews of the major cost drivers.

21. Acquisition Executive and Federal Project Director should develop a process to approve long-lead procurements and early start activities.

After CD-2 approval:

22. Conduct periodic PPPL project peer reviews.

APPENDIX A

CHARGE MEMORANDUM

Department of Energy
Washington, DC 20585

June 28, 2010

MEMORANDUM FOR DANIEL R. LEHMAN
DIRECTOR
OFFICE OF PROJECT ASSESSMENT
OFFICE OF SCIENCE

FROM: EDMUND J. SYNAKOWSKI
ASSOCIATE DIRECTOR OF THE OFFICE OF SCIENCE
FOR THE OFFICE OF FUSION ENERGY SCIENCES

SUBJECT: OFFICE OF SCIENCE PROJECT REVIEW FOR THE NATIONAL SPHERICAL TORUS EXPERIMENT (NSTX) UPGRADE PROJECT

I request that your office organize and conduct an Independent Project Review of the NSTX Upgrade project at PPPL on August 10-11, 2010. The purpose of this review will be to verify the readiness of the project to establish a performance baseline, proceed to final design and initiate early procurement/construction.

The NSTX Upgrade project received Critical Decision (CD)-0 approval in February 2009 and CD-1 approval in April 2010. The project team is currently working to complete preliminary design and will be seeking approval of CD-2, Approve Performance Baseline, and CD-3a, Initiate Early Procurement/Construction of a Limited Number of Work Packages.

In carrying out its charge, the review committee is requested to consider the following questions:

1. Have performance requirements been appropriately and sufficiently defined? Is the preliminary design sound and likely to meet the requirements?
2. Are the cost and schedule estimates credible and realistic to support establishment of the baseline? Do they include adequate contingency?
3. Is the project being managed (i.e., properly organized and adequately staffed) as needed to complete final design and support the project through construction to successful completion?
4. Are environmental, safety & health aspects being properly addressed given the project's current stage of development? Are integrated safety management principles being followed?
5. Is the project documentation (e.g., Project Execution Plan, Hazard Analysis Report) complete and ready for CD-2/3a approval?
6. Is the design adequately mature to initiate CD-3a long-lead procurement?

Barry Sullivan is the program manager for this project and will serve as the contact person for this review. He can be reached at 301-903-8438. I would appreciate receiving your committee's report within 60 days of the review's conclusion.

cc:

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APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the
National Spherical Torus Experiment (NSTX) Upgrade Project
August 10-11, 2010

REVIEW COMMITTEE PARTICIPANTS

Department of Energy

Daniel Lehman, SC, Chairperson

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APPENDIX C

REVIEW AGENDA

Department of Energy Review of the
National Spherical Torus Experiment (NSTX) Upgrade Project
August 10-11, 2010

AGENDA

<u>Tuesday, August 10, 2010—LSB, Room B318</u>

8:00 a.m.	DOE Executive Session	D. Lehman
8:45 a.m.	Welcome/Overview	M. Williams
8:50 a.m.	Laboratory Perspective	S. Prager
8:55 a.m.	Project Overview	R. Strykowsky
9:05 a.m.	NSTX Centerstack Upgrade	L. Dudek
10:20 a.m.	Break	
10:30 a.m.	Second Neutral Beam on NSTX	T. Stevenson
11:30 a.m.	Cost/Schedule and CD-2 Readiness	R. Strykowsky
12:15 p.m.	Lunch	
1:00 p.m.	Tour of NSTX and CS High Bay/Committee Photo	
2:00 p.m.	Subcommittee Breakout Sessions	
5:00 p.m.	DOE Executive Session	
6:00 p.m.	Adjourn	

<u>Wednesday, August 11, 2010</u>

8:00 a.m.	One-on-one breakout discussions as requested with PPPL team members
10:00 a.m.	Subcommittee Working Sessions—Report Writing
11:30 a.m.	Working Lunch (report writing)
12:30 p.m.	DOE Executive Session/Closeout Dry Run
1:30 p.m.	Closeout Presentation (Telcon link to OFES)
2:30 p.m.	Adjourn

APPENDIX D

COST
TABLE

		Project Estimate as of December 2009						DOE Review Team Estimate							
		Cost			Contingency			Cost			Contingency				
Job #	DESCRIPTION	BASE TOTAL ($K)	To Date($K)	To Go ($K)	%	($K)	Total ($K)	BASE TOTAL ($K)	To Date	To Go	%	($K)	Total ($K)	Variance ($K)	Comments
1000	CSU Analytical Support	**$421**		$421	40%	$168	**$589**	$421	$0	$421					
1001	CS Plasma Facing Components	**$1,776**	64.6	$1,711	40%	$724	**$2,500**	$1,776	$65	$1,711					
1002	Passive Plate Analysis & Upgrade Act	**$180**		$180	40%	$72	**$251**	$180	$0	$180					
1200	Vacuum Vessel & Structural Support	**$779**	571.7	$208	40%	$143	**$922**	$779	$572	$208					
1201	Outer TF Structures	**$701**		$701	40%	$280	**$981**	$701	$0	$701					
1202	Outer PF Coil Structures	**$1,128**		$1,128	40%	$451	**$1,580**	$1,128	$0	$1,128					
1203	Umbrella Structural Reinforcement	**$289**		$289	40%	$115	**$404**	$289	$0	$289					
1204	CS Support Pedestal	**$203**		$203	40%	$81	**$284**	$203	$0	$203					
1205	Misc VV Structural Support	**$256**		$256	40%	$102	**$358**	$256	$0	$256					
1301	Outer Toroidal Field Coils	**$726**		$726	15%	$349	**$1,075**	$726	$0	$726					
1303	TF Joint Test Stand & Perform Test	**$338**		$338	25%	$100	**$438**	$338	$0	$338					
1304	Inner TF Bundle (Dsgn/Fab)	**$1,935**		$1,935	40%	$939	**$2,874**	$1,935	$0	$1,935					
1305	OHMIC Heating Coil (OH) DSGN/FAB	**$4,004**	1055.6	$2,948	40%	$1,729	**$5,733**	$4,004	$1,056	$2,948					
1306	Inner Poloidal Field Coils (Shaping)	**$536**		$536	40%	$339	**$875**	$536	$0	$536					
1307	CS Casing Assembly (DSGN/FAB)	**$892**		$892	40%	$357	**$1,249**	$892	$0	$892					
1302	Center Stack Assembly	**$833**		$833	40%	$333	**$1,166**	$833	$0	$833					
2300	Job: 2300 ECH Analysis	**$183**		$183	40%	$173	**$357**	$183	$0	$183					
2420	2nd NBI Sources	**$1,398**		$1,398	10%	$140	**$1,538**	$1,398	$0	$1,398					
2425	BL Relocation	**$1,707**	15	$1,692	25%	$423	**$2,131**	$1,707	$15	$1,692					
2430	2nd NBI Decontamination	**$2,738**	1238.5	$1,499	10%	$150	**$2,888**	$2,738	$1,239	$1,499					
2440	2nd NBI Beamline	**$2,534**	28.6	$2,506	15%	$192	**$2,726**	$2,534	$29	$2,506					
2450	2nd NBI Services	**$3,601**	76.7	$3,524	25%	$931	**$4,532**	$3,601	$77	$3,524					
2460	2nd NBI Armor	**$420**	35.8	$384	15%	$58	**$478**	$420	$36	$384					
2470	2nd NBI Power	**$3,033**	115.2	$2,917	25%	$779	**$3,812**	$3,033	$115	$2,917					
2475	2nd NBI Controls	**$1,769**		$1,769	25%	$442	**$2,212**	$1,769	$0	$1,769					
2480	2nd NBI/TVPS Duct	**$2,665**	183.4	$2,482	15%	$497	**$3,163**	$2,665	$183	$2,482					
2485	Vacuum Pumping System	**$319**		$319	10%	$32	**$351**	$319	$0	$319					
2490	NTC Equipt Relocations	**$3,314**	143	$3,171	40%	$1,634	**$4,949**	$3,314	$143	$3,171					
3200	Water Cooling System Mods for CSU	**$394**	5.4	$388	25%	$97	**$491**	$394	$5	$388					
3300	Bakeout System Mods for CSU	**$82**		$82	10%	$8	**$91**	$82	$0	$82					
3400	Gas Delivery System Mods for CSU	**$91**		$91	25%	$33	**$123**	$91	$0	$91					
4100	Center Stack Diagnostics for CSU	**$888**	11.3	$876	10%	$88	**$975**	$888	$11	$876					
5000	CSU Power Systems	**$8,978**	385.8	$8,593	25%	$2,148	**$11,126**	$8,978	$386	$8,593					
5501	Coil Bus Runs	**$725**		$725	40%	$290	**$1,015**	$725	$0	$725					
6100	Control Sys & Data Acquisition Sys	**$811**		$811	25%	$456	**$1,267**	$811	$0	$811					
7100	Project Mgt & Integration CSU & NBI	**$4,536**	625.8	$3,911	25%	$1,128	**$5,664**	$4,536	$626	$3,911					
7200	Center Stack Management	**$1,381**		$1,381	25%	$452	**$1,833**	$1,381	$0	$1,381					
7300	NB2 Management	**$1,679**	63.3	$1,615	25%	$479	**$2,157**	$1,679	$63	$1,615					
7400	Health Physics Support	**$2,768**		$2,768	25%	$727	**$3,494**	$2,768	$0	$2,768					
7700	NSTX Upgrade HP Allocations	**$1,755**		$1,755	25%	$509	**$2,264**	$1,755	$0	$1,755					
7710	Upgrade Allocations	**$918**	526.3	$392	25%	$118	**$1,036**	$918	$526	$392					
8200	JoCenterstack & Coil Structural Instal	**$5,745**		$5,745	40%	$2,668	**$8,413**	$5,745	$0	$5,745					
8250	Remove/Install Centerstack	**$755**		$755	60%	$649	**$1,404**	$755	$0	$755					
7900	Integrated System	**$71**		$71	40%	$29	**$100**	$71	$0	$71					
x	**Base Estimate =**	**$70,254**	**$5,146**	**$65,108**	**36%**	**$23,360**	**$93,614**	**$70,254**	**$5,146**	**$65,108**					