Department of Energy
Review Committee

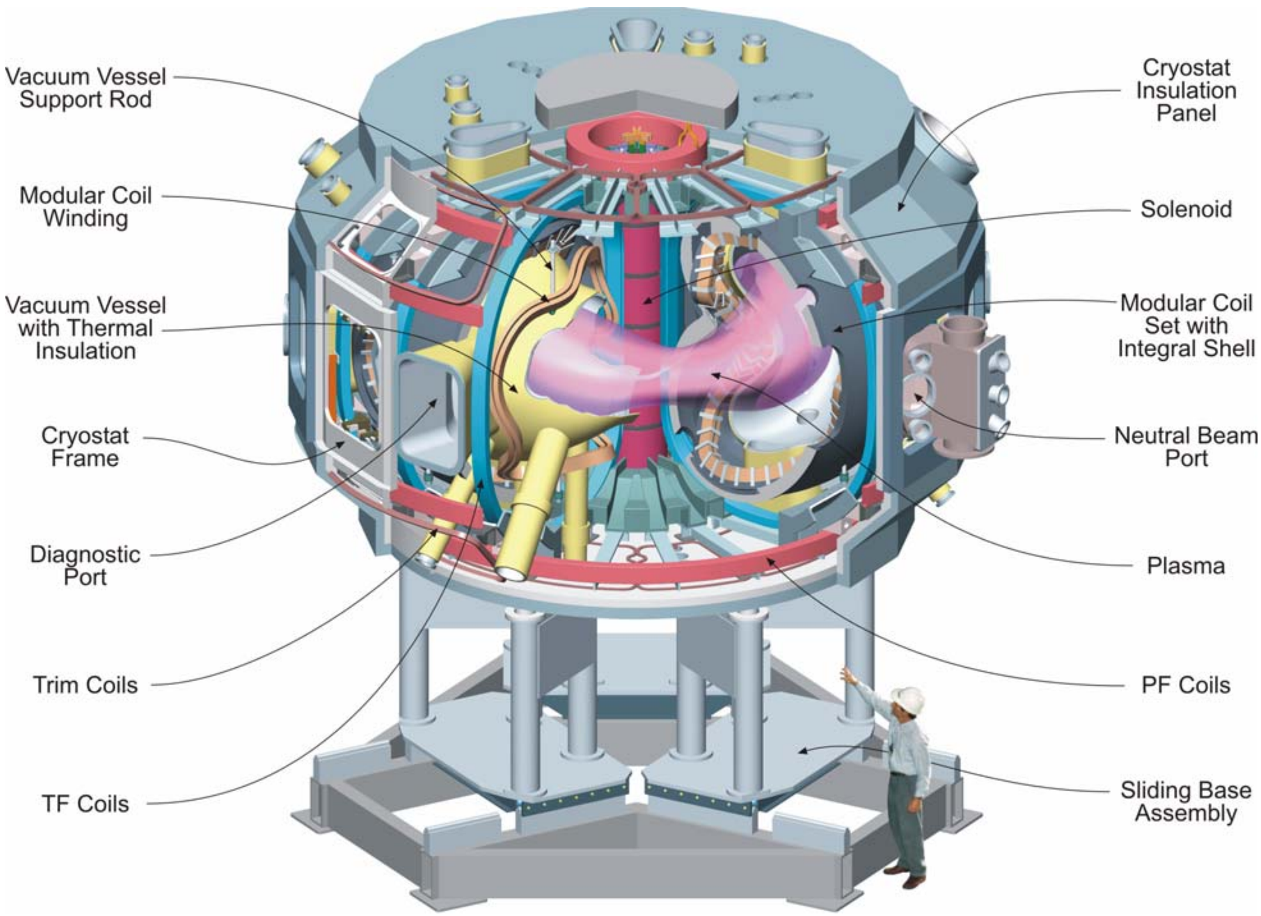
for the

Technical, Cost, Schedule,
ES&H, and Management Review

of the

NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

May 2006



NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science (SC) review of the National Compact Stellarator Experiment (NCSX) project was conducted at the Princeton Plasma Physics Laboratory (PPPL) on May 9-10, 2006 at the request of Dr. N. Anne Davies, Associate Director for the Office of Fusion Energy Sciences. The purpose of the review was to assess the project's current cost and performance. Specifically, the Committee was asked to determine if the procurements for the modular coil winding forms (MCWF) and vacuum vessel subassemblies (VVSA) were proceeding according to the performance baseline; if the project has credible risk management systems in place; if the cost and schedule (including contingencies) are adequate; if appropriate measures to assess and control the cost of "in-house" activities at PPPL have been taken; and if management and labor are adequately staffed.

The NCSX project is an innovative magnetic fusion plasma configuration consisting of a stellarator core that has three field periods and is surrounded by eighteen modular coils (six per field period). A vacuum vessel fills the internal volume of the modular coils to provide the maximum space for plasma shape flexibility. The modular coils are supplemented by toroidal field (TF), poloidal field (PF), and trim coils. Diagnostic systems provide the detailed measurement of the plasma parameters that are critical to the research goals of NCSX.

The integrated project team, including PPPL and Oak Ridge National Laboratory personnel is functioning well and appropriately staffed. The NCSX project is maturing and the MCWFs that appeared to be a major challenge at the November 2005 DOE review now are well into production and are proceeding according to FY 2006 baseline. Two coils have been wound and one has been vacuum impregnated with epoxy. In addition to the progress with the MCWFs, the VVSA fabrication is progressing well and the first VVSA segment has been delivered to PPPL.

The project has made extensive technical progress since the November 2005 DOE review, and is now transitioning from procurement and delivery of components to in-house fabrication and assembly. Thus, the risks in procurement areas have been substantially reduced while significant risks remain with in-house assembly activities. The risk assessment is generally current and credible. However, it is the Committee's opinion that some actions could be taken by the project (i.e., cold-testing of MCWFs and practicing assembly of the machine using unwound MCWFs and VVSA) that may mitigate potential risks. The Committee believed that the project is taking appropriate actions to control the cost of in-house fabrication and assembly, but strong efforts must continue in this area if the project is to reach a successful conclusion. It should be noted that the NCSX project is currently on the SC Watch List.

The Total Estimated Cost for the NCSX project is $92.4 million. As of March 31, 2006, the project has expended approximately $48 million. After a proposed change, the contingency remaining will be $7.9 million or 22 percent of remaining project costs. The project is scheduled for completion in July 2009 with six months of schedule contingency. The Total Project Cost and schedule estimates are credible for this stage of the project. However, the Committee considered cost contingency to be marginal since numerous high-risk activities are yet to be performed.

Based on the information presented by the project, the Committee's recommendations included the following:

- Continue to aggressively track and control in-house costs and reduce modular coil fabrication times without sacrificing quality.

- Assess whether an additional station is necessary for post-potting activities based on realized delivery rates of the modular coil winding forms.

- Expand the verification matrix and present the data at the next review.

- Perform tests that are considered conventional for wound copper magnets.

- Conduct a cost/risk analysis to determine the need for cold-testing on the A1 and B1 coils. Consider structural analysis modeling verification during the cold test.

- Analyze and report on the status of the contingency risks and opportunities identified currently and at the next scheduled DOE review.

- Present at the next DOE review an update of project productivity improvements, cost savings, fabrication activities, and other efficiencies.

- Conduct an external peer review of the field period and machine assembly process and present the detailed schedule and plans at the next DOE review.

- Provide a plan discussing proper safety precautions for the coil and personnel protection during the initial operation and first plasma prior to approval of the project change proposal.

- Determine the best procurement approach for the PF coils.

- Remain vigilant in controlling project cost and continue value engineering.

- Present a draft transition to operations plan by the next DOE review.

There was only one action item resulting from the review: to conduct the next DOE review in approximately six months.

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1. INTRODUCTION

The National Compact Stellarator Experiment (NCSX) is a fusion research project initiated in the Department of Energy (DOE) FY 2003 budget at the Princeton Plasma Physics Laboratory (PPPL). The compact stellarator is one of several innovative magnetic fusion plasma configurations supported by the DOE Office of Fusion Energy Sciences (OFES) and has the attractive potential of operating continuously and without plasma disruptions. Also, when extrapolated to a fusion power plant, the compact stellarator is projected to require low operating power compared with that produced by the power plant.

The mission of NCSX is to acquire the scientific and technological knowledge needed for understanding the behavior of a compact-stellarator plasma, evaluating the attractiveness of this fusion concept, and advancing the state-of-the-art, three-dimensional analysis of fusion plasmas. In 2001, a panel of plasma physicists and engineers conducted a Physics Validation Review (PVR) of the NCSX design. The panel concluded that the physics approach to the NCSX design was appropriate and that the concept was ready for the next stage of development, namely proof-of-principle. The Fusion Energy Sciences Advisory Committee endorsed the panel view. Critical Decision (CD) 0, Approve Mission Need, for NCSX was approved by OFES in May 2001. A May 2002 DOE Conceptual Design Review panel found that the NCSX design concept and project plans provided a sound basis for engineering development. Approval of CD-1, Approve Alternative Selection and Cost Range, by OFES occurred in November 2002.

The NCSX project involves the design, fabrication, installation, and integrated system tests of a compact stellarator core device consisting of a highly shaped vacuum vessel; surrounding coil systems; enclosing cryostat and various auxiliary power; cooling, vacuum, cryogenic, and control systems; as well as a set of startup diagnostics. All of this equipment plus a control room will be located in existing buildings at PPPL that were previously used for other fusion experiments. Further, many of the NCSX auxiliary systems will be made available to the project from equipment used on the previous experiments. The project is being led by PPPL with Oak Ridge National Laboratory (ORNL) providing major leadership and support as a partner.

Because the project involves the fabrication of new equipment and considerable re-use of existing facilities and hardware systems and minimal civil construction, DOE designated the project as a Major Item of Equipment (MIE) and included it as such in the FY 2003 budget. The cost initial range of NCSX, based on the pre-conceptual design, was between $69-83 million.

The Total Estimated Cost (TEC) of the device based on the conceptual design was $73.5 million with a completion in June 2007. Due to the continuing resolution at the beginning of FY 2003 that was not resolved till February 2003, the project did not start until April 2003 instead of the planned October 2002 start. With this later start and additional design and cost information, PPPL estimated the TEC of the device to be $81 million with a completion in September 2007. PPPL assembled an outside committee to perform a preliminary design review in October 2003. Upon completion of the review and after analyzing the impacts from recommendations of that committee, the project team estimated the NCSX TEC to be $82 million with a completion date of November 2007. In addition, the preliminary design review committee concluded that the project was ready to proceed to CD-2, Approve Performance Baseline (which was approved in February 2004 with a baseline TEC of $86.3 million and a completion date in May 2008 after incorporating recommendations from the November 2003 Performance Baseline Review and updated DOE funding profile).

After various reviews, CD-3, Start of Construction, was approved in September 2004, with a TEC of $86.3 million and a completion date in May 2008. In 2005, the NCSX funding profile was modified by OFES in response to budgetary constraints. A new baseline was developed and approved by the Deputy Secretary in July 2005. This new baseline established a TEC of $92.4 million and a July 2009 completion date.

2. TECHNICAL SYSTEMS EVALUATIONS

The major components of the stellarator core are the modular coils (MC) and vacuum vessel subassemblies (VVSA). Additional components discussed were the toroidal field coils (TF).

2.1 Modular Coil Winding Forms and Modular Coil Winding Process

The MCs are formed by winding and potting flexible cable into cast and machined modular coil winding forms (MCWF). These are being fabricated by the Energy Industries of Ohio (EIO). Coil winding and potting are being conducted in-house at PPPL. The first MC has been wound, potted, and warm-tested successfully and the project is to be commended for this success.

2.1.1 Findings

All 18 MCWF’s have been cast and only four remain to be shipped from the foundry for the machining operation. Five of the MCWF’s have been completed and received by PPPL for winding and are in process.

PPPL has worked successfully with EIO and EIO’s machining subcontractor, Major Tool and Machine (MTM) to bring the MCWF fabrication under control through optimized machining processes, simplified metrology, contract incentives, and relaxed tolerances in non-critical locations. Although machining development effort was significant on the first three MCWF’s type-C modules, PPPL does not expect such significant development to pertain to the forthcoming module types A and B, although they have somewhat different geometry. The incentives have the added benefit of encouraging delivery of form-types (A, B, and C) in a sequence to expedite assembly operations.

The first modular coil has been wound, potted, and warm-tested successfully. Cold-testing is scheduled for early June 2006. After incurring a first-article winding and potting cost that was more than two times the budgeted cost, PPPL has since done a commendable job of bringing down the winding costs. Vacuum Pressure Impregnation (VPI) process time, which cost more than planned due to a decision to overstaff the operation on the first article as a precautionary measure, is included in the estimate. Ongoing efforts continue to focus on ways to improve the coil fabrication process and further reduce in-house fabrication costs.

2.1.2 Comments

The project should consider whether there is any advantage or risk mitigation incurred by cold-testing a coil of the "B" and "A" types in addition to the planned testing of "C1". In concert with the cold-test, the project should consider whether there is some means of simulating operating voltage to ground conditions during the cold-test.

The project should reconsider whether there is some practical means of performing warm turn-to-turn voltage testing.

One possible cost saving activity in the coil VPI process was to reduce the number of epoxy feed points. This change would seem to offer little in the way of cost reduction, may come at great risk, and should probably not be done.

The Committee believed the project to be taking appropriate measures to bring the MCWF deliveries back to the project schedule.

The Committee suggested that PPPL should practice rigging of a MCWF 3-pack on either an off-critical path vacuum vessel sector or on a vacuum vessel sector mockup. The MCWF 3-pack, without coils, should provide a reasonable simulation of the fully-loaded MCWF with coils and provide practice in rigging manipulations with an object having a center of mass that is radially non-symmetric.

2.1.3 Recommendations

1. The project should continue its aggressive behavior to track and control the in-house costs and work to improve winding speed without sacrificing quality.

2. Assess whether an additional station is necessary for post-potting activities based upon realized delivery rates of the MCWF.

3. Perform a cost/risk analysis to determine whether there is any advantage or risk mitigation gained by cold-testing a coil of the "B" and "A" types in addition to the planned testing of "C1".

2.2 Vacuum Vessel Sub-Assembly

2.2.1 Findings and Comments

The first VVSA has been delivered to PPPL. The second section is ready for leak checking and ports are being welded onto the final section. The delivery schedule has slipped slightly from the planned schedule; however, this slip is not significant as work can commence on the delivered item and will not impact project schedule (VVSA is nine months off critical path).

A solution has been found to accommodate a slight variance from tolerance in the spacer section between field period joints. Tolerance conditions improved on VVSAs #2 and #3.

The Committee believed that this aspect is progressing well with all items to be delivered by the end of the fiscal year and virtually no cost growth over the original contracted price.

2.2.2 Recommendations

None.

2.3 Toroidal Field Coils

2.3.1 Findings

The project has investigated two different outside vendors for fabrication of the TF coils and their associated support/alignment wedging. Everson-Tesla has been chosen as the TF coil vendor. Scheduled deliveries maintain a buffer from the critical path.

The TF coil contract also includes production of the wedge supports, which are now machined weldments instead of castings, resulting in a cost reduction over the last procurement effort.

2.3.2 Comments

There is limited experience with Everson-Tesla as a manufacturing entity while under Tesla ownership.

Staffing levels are apparently lower than they were when Everson was independent.

Careful, frequent, and perhaps continual PPPL oversight will be required to ensure the work is being properly executed, and that quality requirements are being met.

2.3.3 Recommendations

None.

2.4 Machine Assembly and Test

2.4.1 Findings and Comments

A verification matrix is apparently available in the systems engineering documents. However, expansion of the matrix to enable tracking the test results, providing an easy means of like-article comparisons, and facilitating presentation of results to reviewers would also support an in-control manufacturing process for the NCSX. In-control manufacturing means that each subassembly is verified as sound by inspection and test before it is integrated into the next higher subassembly. Thus, the expanded matrix should clearly identify the tests that are conducted at each stage of the manufacturing and assembly sequence.

2.4.2 Recommendations

1. PPPL should expand the verification matrix as described above and present the expanded matrix at the next DOE review.

2. Every effort should be made to perform those tests that are considered conventional for wound copper magnets.

3. PPPL should also consider the benefits of structural analysis modeling verification during the cold-test despite the fact that the loads are different than in the final system configuration. Any verification of the structural model adds validity to the model and the design process overall.

3. COST ESTIMATE

3.1 Findings

The NCSX baseline TEC remains at $92.4 million and the project reported that $47.9 million had been expended through March 31, 2006. This equates to 55.4 percent of the project having been completed, compared against a 57.6 percent planned completion. Approximately, $8 million of that amount was accrued in the last six months due to the increased pace of vendor production (MCWFs and VVSAs) and the commencement of MC winding operations at PPPL. The Cost Performance Index at that point was 0.96, which was calculated from April 2003 onward (when the project started) and includes the directed baseline change in July 2005. The project recently completed its semi-annual Estimate-to-Complete (ETC) that indicated there is approximately $36.5 million worth of remaining work.

There is $7.9 million remaining in contingency (assuming approval of an $824K pending Engineering Change Proposal), a $1.7 million drop compared to the Engineering Change Proposal that was reported at the November 2005 DOE review, and subsequently approved. The percentage of contingency on the remaining work has declined more modestly to under 22 percent (compared to 22 percent previously), factoring in all the unrecoverable cost variances which currently exist. The ETC exercise recognized some out-year cost risks, for MC winding operations and MCWF vendor performance incentive payments, that management has elected (for valid reasons) to exclude at this time. The costs of these risks total $920K. When factoring in the unrecoverable cost variances, the contingency would be a little below 20 percent, which is marginal for a project of this complexity.

3.2 Comments

Contingency continues to be very tight, as PPPL, NCSX, and the DOE Princeton Site Office (PSO) management are all acutely aware. Risks have been substantially retired in some key areas of the Stellarator Core (the Modular Coils and Vacuum Vessel). For instance, the MC winding costs on the second and third units have come down significantly to a level aligned with the base estimate, and the rate of MCWF vendor deliveries has improved because of renegotiating financial incentives into their contract. The Committee was pleased to note that Princeton University facilitated this renegotiation, and committed to absorb the last $300K of costs for these financial incentives if the vendor meets the stretch production goal. All three VVSA sectors appear to be on track for delivery during summer 2006. Having the TF Coils under a fixed-price contract with

Everson-Tesla has also helped. In general, the project has responded appropriately to assess and control in-house fabrication and assembly activities. There has been detailed tracking and analysis of PPPL labor hours and costs on the two MCs wound to date. Continued management attention in this area will be necessary for success.

On the other hand, some new risks have been identified (e.g., MC shear loads) and are now coming into focus. Approximately, 75 percent of the fabrication/assembly activities remain. In particular, field period assembly still exists as a future high-risk activity, one that warrants at least the 47 percent contingency assigned to it. Machine assembly, a separate activity, is assigned 35 percent. These two activities comprise $3.0 million of the remaining $7.9 million of contingency. The Committee is concerned that damage to MC(s) and/or VVSA(s) during assembly could potentially consume all and more of the contingency. Hence, the need for thorough preparation and extreme care in completing those operations.

Overall, risks appear to be well managed. The project has been proactive in identifying emerging risk areas, developing mitigation measures, and tracking them using a “critical issues” list. The risk analysis appears to be detailed and well planned. It is commendable that NCSX management has imposed an aggressive philosophy concerning continued value engineering in order to find cost savings wherever possible ($2.4 million in recently implemented actions). Nonetheless, contingency usage over the past six months has been uncomfortably high and cannot continue at that rate without seriously jeopardizing the cost baseline. There is a short list of potential savings that could still be achieved, principally in the ancillary systems. Examples of those would include the prospect of collaborating with Academia Scinica Institute for Plasma Physics (ASIPP) on production of the poloidal field (PF) coils, and simplifying the cryostat design. The Committee was not optimistic that there are sources of major savings that have been overlooked.

Lastly, it was noted that the NCSX project bears the same overhead rate as the rest of the Laboratory. Based on the current contingency situation, PPPL and DOE should explore the possibility of reducing the overhead rate applied to NCSX if it could be justified through a causal/beneficial analysis.

3.3 Recommendations

1. Analyze and report on the status of the contingency risks and opportunities identified currently and at the next DOE review.

2. Present at the next DOE review an update of demonstrated project productivity improvements, cost savings, fabrication activities, and other efficiencies.

3. Explore the possibility of reducing the overhead rate applied to NCSX if it could be justified through a causal/beneficial analysis.

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4. SCHEDULE and FUNDING

4.1 Findings

By the end of March 2006, the project was 36 months into a 76-month long schedule. The NCSX baseline schedule calls for an early finish in January 2009, leaving six months of schedule contingency to the baseline date for CD-4, Approve Start of Operations, in July 2009. This reflects one month of schedule contingency gain since the November 2005 DOE review. The Schedule Performance Index (0.96) was reported as of March 31, 2006. The project critical path has remained largely unchanged. It runs through MCWF production and MC winding, then through field period assembly, and finally through cryostat installation, pump-down, and integrated system testing. All R&D is essentially complete, and over 80 percent of all Title I and II design work has been finished.

The MCWF vendor's (EIO) schedule performance appears to have improved as a result of adding financial incentives to the contract, and there is reasonable confidence that MCWF deliveries will meet the project's early finish schedule requirements, which requires deliveries every five weeks. The project must produce one MCWF every four weeks to earn the maximum fee; recent results indicate an actual rate of one every four to five weeks following a 24/6 working schedule. The VVSA vendor (MTM) has also been quite responsive. The project is considering the option of establishing a third MC winding station (at an estimated additional cost of around $70K) that could accelerate the MC winding process. A decision on whether to exercise that option will be made in the next few months depending on the rate of MCWF deliveries. NCSX management recognizes that the key elements of cost control are in encouraging more efficient work processes (through Value Improvement Proposals) and in finding economical ways to accelerate the overall schedule.

Since the November 2005 DOE review, uncertainties associated with the schedules for MCWF production and MC winding operations have significantly diminished. Other major parallel activities, such as VVSA and TF Coil production, lie well off of the critical path. The project prepares very detailed near-term schedules six months into the future in a "rolling wave" approach to determine PPPL manpower requirements and identify issues. NCSX receives due priority from PPPL management in the allocation of resources.

Field period and machine assembly operations are currently planned using a single shift per day. The project has an alternative plan to operate two shifts per day and there appears to be adequate staff resources to do this provided that the extra personnel can be trained in time to support the schedule.

The current Project Assessment and Reporting System (PARS) status indicator for NCSX is "Yellow" due to earlier concerns about the schedules for MCWF deliveries. As previously noted, this situation appears to be improving.

As reflected in Table 4-1, the FY 2006 Budget Authority (BA) was increased by $1.1 million since the November 2005 DOE review. Based on the project's Budgeted Cost for Work Schedule (BCWS) plan for a January 2009 early finish, most of the available contingency falls in FY 2008.

Table 4-1. NCSX Funding Profile and Contingency Distribution as a Result of BCWS ($M)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09	Total
BA	$7.9	$15.9	$17.5	$17.0	$15.9	$15.9	$2.3	$92.4
Contingency				$0	$1.0	$6.1	$0.8	$7.9

4.2 Comments

Due to the nature of the critical path schedule that requires producing the MCWFs, winding the MCs, and then assembling them with the VVSA into the Stellarator Core, the project's six months of schedule contingency is appropriate. The Committee was, however, concerned that the re-planning effort after the November 2005 DOE review appeared to compress some of the field period assembly activities. This area will need to be examined in more detail as this important phase of the project approaches. The project described a plan to perform field period assembly using the Tokamak Fusion Test Reactor (TFTR) overhead bridge crane instead of a special fixture originally designed for that purpose. A feasibility test has been conducted with a concrete block substituting for MCs. The Committee is concerned that the schedule risk involved may not be fully appreciated without having performed a more realistic simulation of this process, or at least subjecting the plan to a comprehensive external peer review.

There is a high potential of using more than the allotted $1.0 million of contingency during FY 2007, when field period assembly begins and PPPL manpower is projected to reach its peak. This would mean shifting work into FY 2008, and possibly consuming schedule contingency as well if the affected activities are on the critical path. Accelerating some BA from FY 2008 to FY 2007 would be an assistance.

4.3 Recommendation

1. Conduct an external peer review of the field period and machine assembly process. Present at the next DOE review the detailed schedule and plans for carrying out field period and machine assembly.

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5. ENVIRONMENT, SAFETY and HEALTH

5.1 Findings

The NCSX has integrated Environment, Safety and Health (ES&H) planning in all aspects of its work and has an excellent safety record. There have been no time loss accidents and only one non-DART (Days-Away-Restricted-Transferred) case occurrence for the project. Up to this point, while a majority of NCSX work has been performed by vendors, there has nonetheless been a significant amount of in-house work, with ES&H oversight are currently covered under the PPPL safety umbrella, wherein line management is responsible for project ES&H. As the NCSX components are being delivered to PPPL and an increasing amount of work is starting to be performed in-house, especially when the assembly of components starts, staff support by the Laboratory's ES&H organization will increase accordingly. Line management remains responsible for the project ES&H.

On May 4, 2006, the project was awarded the Governor's Occupational Safety and Health Award.

5.2 Comments

The ES&H aspects of the NCSX are being adequately and proactively addressed at this stage of the project. The project holds toolbox meetings, develops job hazard analysis for new tasks, and performs safety inspections and other safety activities.

An example of a proactive safety practice is the recognition by the project to have a more stable and balanced MCWF fixture while winding the forms. This was accomplished using weights to stabilize the MCs while they are being wound.

In an effort to find additional cost savings, the project has been performing ongoing value engineering analysis to modify work scope and processes. A few of the scope modifications include substitution of locks for interlocks, use of an existing pumping system, and the use of existing operations procedures instead of writing new procedure for the startup process. The Committee did not see any major safety concerns with the proposed scope reductions with the exception of the use of locks and physical barriers instead of the interlock controls, and the simplified coil protection approach.

For the initial operation and first plasma, the use of locks and alternative electrical power distribution for the simplified coil protection should not be an issue with proper safety precautions implemented including coil and personnel protection.

5.3 Recommendation

1. Provide a plan for proper safety precautions for the coil and personnel protection during the initial operation and first plasma prior to approval of the project change proposal, which would modify/simplify these systems.

6. MANAGEMENT

The NCSX is maturing. The MCWF, that appeared to be a major challenge at the November 2005 DOE review, are currently well into production. MCWFs are expected to be delivered about every four to five weeks. Two coils have been wound at the laboratory and one has been vacuum impregnated with epoxy.

Although the time to wind and produce the first item of the MC was very high, the current winding times for the last two MCWFs are near the original estimate, which indicates a good understanding of the manufacturing process.

A resource-loaded schedule for the remainder of the project was presented that indicated about a six-month contingency in the schedule. Overall, the cost contingency is about 22 percent of the remainder of work. However, the Committee considered this marginal since high-risk activities (i.e., winding and production of most MCs, VVSA assembly, and machine assembly) are yet to be performed.

6.1 Findings

A revised incentive contract was renegotiated with the MCWF supplier, EIO, regarding the delivery of the units.

A contract was signed with Everson-Tesla for the fabrication of TF coils including the center wedges.

The project is continuing value engineering efforts.

The project is moving to the production stage where the majority of the fabrication is in-house.

6.2 Comments

PPPL, ORNL, and DOE/PSO management continue to place a very high priority on NCSX and provide regular oversight of the project.

Projections of successful deliveries of the MCWF and favorable winding times in-house, indicate that completion within the budget may be attainable.

There appears to be a good understanding by management of the resource-loaded schedule requirements. Planning for adequate personnel to execute the project was presented.

The cost contingency is marginal and will require detailed follow-up by management.

The funding profile may affect the work schedule particularly FY 2007. Additional BA shifted from FY 2008 to FY 2007 would help reduce schedule risk.

Integrated Safety Management appears to be well executed from management downward.

This is the appropriate time to initiate planning for the transition to operations.

6.3 Recommendations

1. Determine the best procurement approach for the PF coils.

2. Remain vigilant in controlling project cost and continue value engineering.

3. Present a draft transition to operations plan by next DOE review.

APPENDIX A

CHARGE MEMORANDUM

Department of Energy
Washington, D.C. 20585

March 13, 2006

MEMORANDUM FOR: Daniel R. Lehman, Director
Construction Management Support Division

FROM: N. Anne Davies (signed)
Associate Director for Fusion Energy Sciences

SUBJECT: Cost and Schedule Review of the National Compact Stellarator Experiment (NCSX) at the Princeton Plasma Physics Laboratory (PPPL)

I would like to request that your office organize and lead an Office of Science (SC) review of the NCSX project.

The purpose of this review is to evaluate the project's current cost and schedule performance. This information will help SC determine that the NCSX Project is meeting the SC project performance goals, and provide recommendations to address any issues you may discover.

The review shall be conducted on May 9-10, 2006, at PPPL. In carrying out its charge, the review committee should respond to the following questions:

1. Does the project performance to date support the conclusion that the procurements for the modular coil winding forms and vacuum vessel assemblies are now proceeding according to the FY 2006 performance baseline for the project?

2. Is the project risk assessment current and credible? Are there realistic mechanisms in place for evaluating and resolving any future project risks, including technical issues and changes, which may arise?

3. Has the project taken appropriate measures to assess and control the cost of in-house fabrication and aseembly activities?

4. Are the project's cost and schedule estimate credible and realistic for this stage of the project? Do they include adequate cost and schedule contingency? Does the contingency reflect a thorough risk based analysis?

5. Is the Integrated Project Team and the PPPL/ORNL Project Team appropriately staffed and functioning as defined in DOE Order 413.3 and the Project Execution Plan?

Barry Sullivan, NCSX program manager, will work closely with you as necessary to plan and carry out this review. I would appreciate receiving your Committee's report within 30 days of the conclusion of the review. This review will play an important role in ensuring that the NCSX project can be completed on cost and schedule. Thank you for your help in this matter. If you have any questions or need additional information, please contact Barry at 301-903-8438.

cc:
B. Kong, OECM
K. Chao, SC-1.3
S. Meador, SC-1.3
K. Summers, SC-1.21
B. Sullivan, SC-24.2
G. Pitonak, PSO
J. Faul, PSO
R. Goldston, PPPL
R. Hawrylik, PPPL
H. Neilson, PPPL
J. Lyon, ORNL

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the
National Compact Stellarator Experiment (NCSX)

REVIEW COMMITTEE PARTICIPANTS

Department of Energy

Kin Chao, DOE/SC, Chairperson

Consultants

Dave Anderson, U. of Wisconsin
Brad Smith, MIT
Jeff Hoy, DOE/SC
Bruce Strauss, DOE/SC

Observers

Barry Sullivan, DOE/SC
Jeff Makiel, DOE/PAO
Greg Pitonak, DOE/PAO

APPENDIX C

REVIEW
AGENDA

Department of Energy Review of the
National Compact Stellarator Experiment (NCSX)

AGENDA

Tuesday, May 9, 2006, Room LSB-318

8:00 am	DOE Executive Session	K. Chao
8:45 am	PPPL Welcome	R. Goldston
8:50 am	Project Overview and Management	H. Neilson
9:50 am	Stellarator Core Design	B. Nelson
10:20 am	Break	
10:30 am	MCWF Procurement	P. Heitzenroeder
11:00 am	VVSA Procurement	M. Viola
11:20 am	TF Procurement	M. Kalish
11:40 am	On-Site Fabrication Overview	L. Dudek
12:00 pm	Lunch	
12:45 pm	Tour of NCSX Manufacturing Facility	
1:30 pm	Coil Winding	J. Chrzanowski
1:50 pm	Field Period Assembly	W. Reiersen
2:10 pm	Break	
2:20 pm	Risk Assessment Summary	W. Reiersen
2:50 pm	Cost and Schedule Summary	R. Strykowsky
4:00 pm	DOE Executive Session	
5:00 pm	Feedback/Questions to Project Team	
6:00 pm	Adjourn	

Wednesday, May 10, 2006, Room LSB-318

8:00 am	DOE Executive Session
8:30 am	Discussion/Responses from Project Team
10:00 am	Report Writing
12:00 pm	Lunch
12:45 pm	Closeout Dry-run
2:00 pm	Closeout (video conference with OFES)
3:00 pm	Adjourn

APPENDIX D

COST TABLE

NCSX Cost Baseline

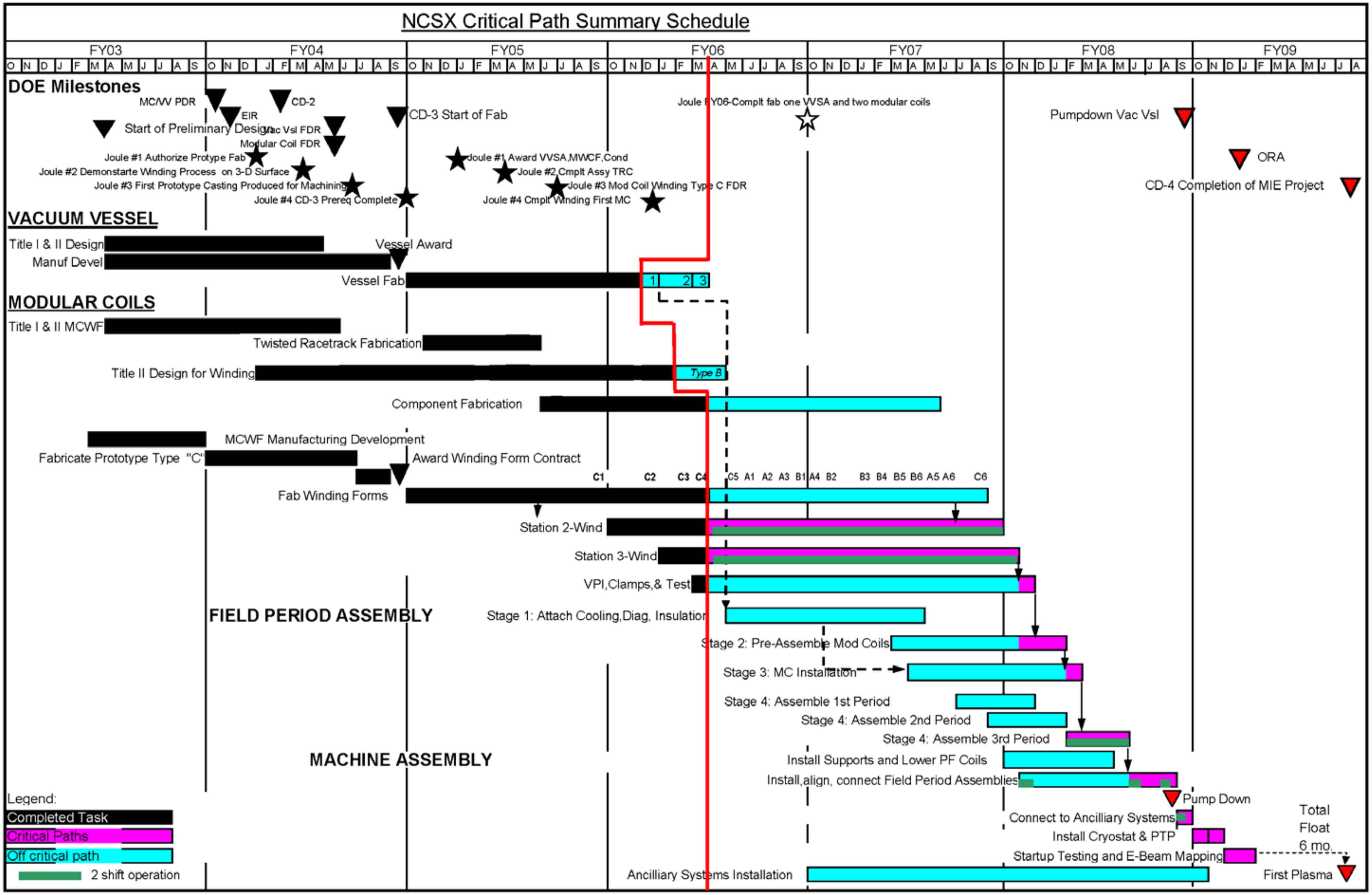
WBS	WBS Title	Project Estimate					
		Base Cost ($K)	Base To Date Cost	Base To Go Cost	Contingency %	Contingency $	Total ($K)
1	**Stellarator Core Systems**	**61,345,832**	**37,547,620**	**23,798,212**	**23.8%**	**5,670,479**	**67,016,312**
11	In Vessel Components		0	0			0
12	Vacuum Vessel Systems	9,727,277	8,040,019	1,687,258	9%	156,558	9,883,835
13	Conventional Coils	5,261,618	2,098,295	3,163,323	16%	514,607	5,776,225
14	Mod Coils	33,533,444	23,387,324	10,146,120	19%	1,887,603	35,421,047
15	Coil Support Structures	1,330,120	82,401	1,247,719	32%	398,126	1,728,246
16	Coil Services	1,134,440	2,792	1,131,648	25%	280,748	1,415,188
17	Cryostat & Base Support Structure	1,578,865	414,775	1,164,090	30%	344,644	1,923,508
18	Field Period Assembly	6,008,769	1,775,648	4,233,121	47%	1,985,701	7,994,470
19	Stellarator Core Mgmt. & Integration	2,771,299	1,746,366	1,024,933	10%	102,493	2,873,793
2	**Plasma Heating Fueling & Vac Systems**	**485,159**	**347,909**	**137,250**	**14%**	**19,215**	**504,374**
21	Fueling Systems	150,986	62,893	88,093	14%	12,333	163,319
22	Torus Vacuum Pump	49,157	-	49,157	14%	6,882	56,039
23	Wall Conditioning System	-					0
25	Neutral Beam Injection System	285,016	285,016	-			285,016
3	**Diagnostics**	**971,357**	**678,515**	**292,842**	**30%**	**88,102**	**1,059,460**
31	Magnetic Diagnostics	592,758	375,656	217,102	30%	65,130	657,888
36	Edge & Divertor Diagnostics	9,581	0	9,581	20%	1,916	11,497

38	Electron Beam (EB) Mapping	30,197	0	30,197	34%	10,267	40,464
39	Diagnostics Integration	338,822	302,859	35,963	30%	10,789	349,610
4	**Electrical Power Systems**	**3,165,883**	**713,298**	**2,452,585**	**19%**	**477,399**	**3,643,282**
41	AC Power	354,638	107,351	247,287	18%	44,512	399,150
43	DC Systems	720,796	384,666	336,130	18%	60,503	781,299
44	Control & protection system	1,027,599	81,687	945,912	20%	185,457	1,213,056
45	Power System Design & Integration	1,061,550	138,294	923,256	20%	186,927	1,248,477
46	FCPC Building Modification	1,300	1,300	0	0	-	1,300
5	**Central I&C Systems**	**841,902**	**33,022**	**808,880**	**10%**	**78,238**	**920,139**
51	TCP/IP Infrastructure System	173,900	0	173,900	5%	8,695	182,595
52	Central Instrumentation & Controls System	146,660	0	146,660	10%	14,666	161,326
53	Data Acquisition & Facility Computing	152,216	0	152,216	16%	24,355	176,570
54	Facility Timing & Synchronization System	92,852	0	92,852	14%	12,999	105,851
55	Real Time Plasma & Power Control Systems	93,615	0	93,615	8%	7,489	101,105
56	Central Safety Interlock System	125,419	0	125,419	8%	10,034	135,452
58	Central I&C management and Integration	57,239	33,022	24,217		-	57,239
6	**Facility Systems**	**600,452**	**24,243**	**576,209**	**20%**	**115,242**	**715,693**
61	Water Cooling Systems	29,145	14,873	14,272	20%	2,854	31,999
62	Cryogenic System	455,033	0	455,033	20%	91,007	546,040
63	Utility Systems	116,274	9,370	106,904	20%	21,381	137,655
65	Facility System				0		0

		-					
7	**Test Cell Preparation & Machine Assy**	**4,440,443**	**941,616**	**3,498,827**	**29%**	**1,008,480**	**5,448,924**
71	Shield Wall Reconfiguration	32,635	32,635	0		-	32,635
72	Control Room Refurbishment	(0)	0	0	10%	(0)	0
73	Platform Design	113,547	75,940	37,607	10%	3,644	117,191
74	Planning/Oversight	1,774,555	833,041	941,514	15%	143,084	1,917,639
75	Machine Assembly Planning & Oversight	2,281,928	0	2,281,928	35%	804,685	3,086,613
76	Tooling Design & Fabrication	237,779	0	237,779	24%	57,067	294,845
8	**Project Oversight & Support**	**12,684,949**	**7,745,807**	**4,939,142**	**9%**	**440,480**	**13,125,429**
81	Project Management & Control	4,423,309	2,638,335	1,784,974	5%	89,249	4,512,557
82	Project Engineering	5,360,364	3,648,997	1,711,367	5%	79,568	5,439,932
84	Project Physics	470,016	470,016	0			470,016
85	Integrated System Testing	798,742	0	798,742	26%	207,257	1,005,999
A	Allocations	1,632,518	988,459	644,059	10%	64,406	1,696,924
	YTD cost variance		-107,000				-107,000
	TOTAL	**84,428,977**	**47,925,030**	**36,503,947**	**21.6%**	**7,897,635**	**92,326,612**
	DCMA	75,000	75,000				75,000
		84,503,977	48,000,030				**92,401,612**

APPENDIX E

SCHEDULE CHART



NCSX Critical Path Summary Schedule
FY03
FY04
FY05
FY06
FY07
FY08
FY09
DOE Milestones
MC/VV PDR
EIR
CD-2
Start of Preliminary Design
Vac Vsl FDR
Modular Coil FDR
CD-3 Start of Fab
Joule FY06-Complt fab one VVSA and two modular coils
Pumpdown Vac Vsl
ORA
CD-4 Completion of MIE Project
Joule #1 Authorize Protype Fab
Joule #2 Demonstarte Winding Process on 3-D Surface
Joule #3 First Prototype Casting Produced for Machining
Joule #4 CD-3 Prereq Complete
Joule #1 Award VVSA,MWCF,Cond
Joule #2 Cmplt Assy TRC
Joule #3 Mod Coil Winding Type C FDR
Joule #4 Cmplt Winding First MC
VACUUM VESSEL
Title I & II Design
Manuf Devel
Vessel Award
Vessel Fab
1
2
3
MODULAR COILS
Title I & II MCWF
Twisted Racetrack Fabrication
Title II Design for Winding
Type B
Component Fabrication
MCWF Manufacturing Development
Fabricate Prototype Type "C"
Award Winding Form Contract
Fab Winding Forms
C1 C2 C3 C4 C5 A1 A2 A3 B1 A4 B2 B3 B4 B5 B6 A5 A6 C6
Station 2-Wind
Station 3-Wind
VPI,Clamps,& Test
FIELD PERIOD ASSEMBLY
Stage 1: Attach Cooling,Diag, Insulation
Stage 2: Pre-Assemble Mod Coils
Stage 3: MC Installation
Stage 4: Assemble 1st Period
Stage 4: Assemble 2nd Period
Stage 4: Assemble 3rd Period
MACHINE ASSEMBLY
Install Supports and Lower PF Coils
Install,align, connect Field Period Assemblies
Pump Down
Connect to Ancilliary Systems
Install Cryostat & PTP
Startup Testing and E-Beam Mapping
Ancilliary Systems Installation
Total Float 6 mo.
First Plasma
Legend:
Completed Task
Critical Paths
Off critical path
2 shift operation

APPENDIX F

ACTION ITEMS

Action Items
Resulting from the May 9-10, 2006
Department of Energy Review of the
NCSX Project

Action	Responsibility	Due Date
1. Conduct a DOE review	SC/NCSX	within 6 months