Department of Energy
Review Committee

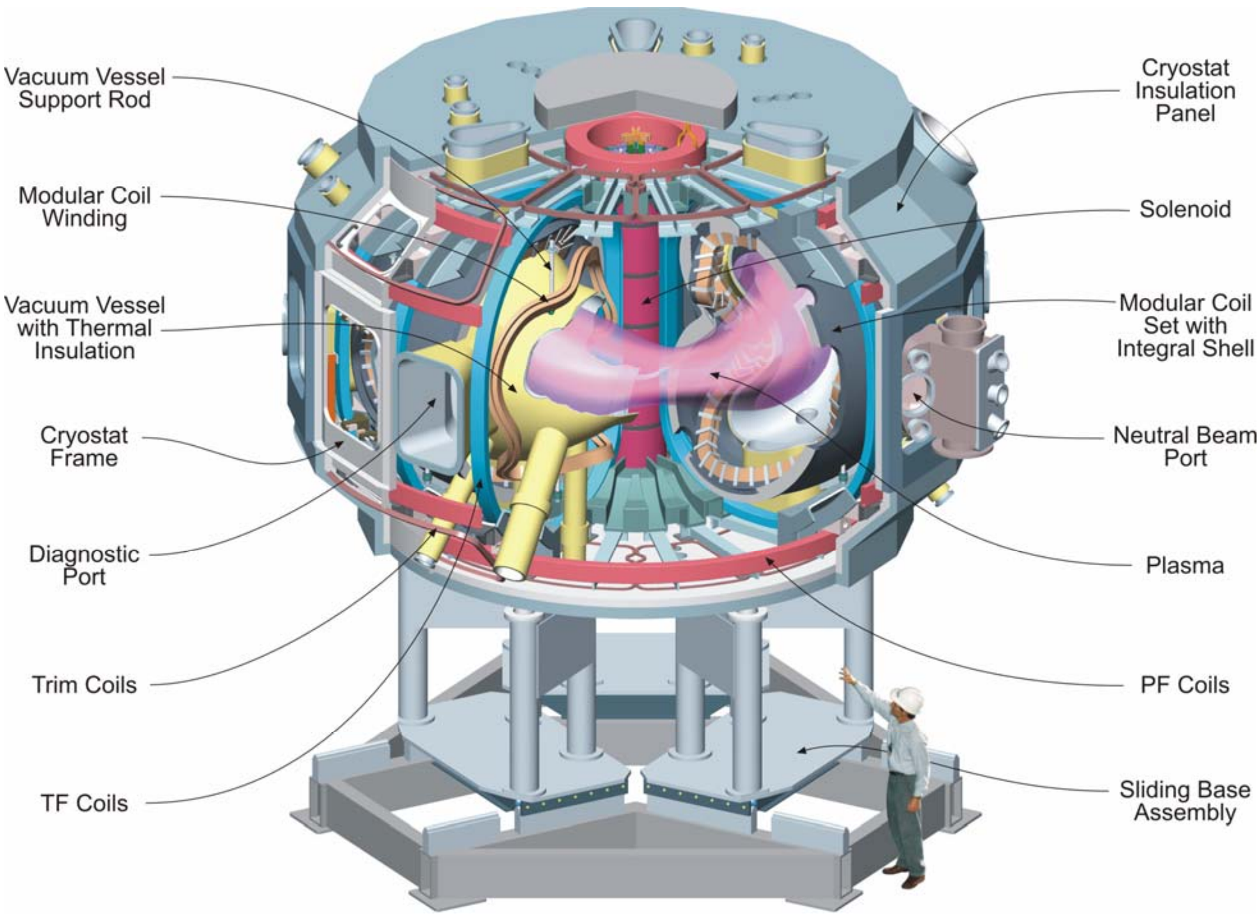
for the

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

of the

NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

August 2007



NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

EXECUTIVE SUMMARY

As requested by Dr. Raymond Fonck, the Associate Director for Fusion Energy Sciences (OFES), Office of Science, a Department of Energy Independent Project Review of the National Compact Stellarator Experiment (NCSX) Major Item of Equipment was performed at Princeton Plasma Physics Laboratory (PPPL) from August 15-17, 2007. The purpose of the review was to evaluate the credibility and reasonableness of the project's latest cost and schedule estimates, and the proposed project's path forward. The Committee did not evaluate the scientific merit of the NCSX project against other possible initiatives in the fusion program.

The project presented a proposed baseline increase to the NCSX Total Project Cost (TPC) by $40 million (from $102 to $142 million) and extends the completion date by 29 months (from July 2009 to December 2011). The new estimates include $14.4 million or approximately 28 percent cost contingency and 11 months or approximately 24 percent schedule contingency. The project estimates were developed using a detailed "bottoms-up" approach with contingency based on probabilistic methodology.

Technically, the integration of design activities is not ideal and proper resources should be added to address systems engineering and design integration. However, significant engineering, design, and technical issues were resolved over the past months and detailed assembly plans and equipment were developed. The Committee did not identify other additional technical "show-stoppers" that threaten the completion of Field Period or Final Machine Assemblies.

The predominant reason for the deviation from the DOE approved baseline is that the earlier estimates did not reflect adequate understanding of the complexity and tight tolerances necessary to meet the requirements of this first-of-a-kind stellarator. This increased understanding was gained through PPPL and Oak Ridge National Laboratory experience with the assembly of the magnet coils and detailed design for the final assembly process. PPPL believes that more design work earlier would have revealed these technical issues sooner, but would not have substantially reduced the magnitude of the new estimate. The constraint on annual funding level has served to exaggerate the increases due to extending the project's completion date and thus the project's cost.

Based on information the NCSX project presented, the Committee judged that the new estimated TPC and CD-4, Approve Start of Operations, date are achievable.

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, poloidal field, and trim coils. Diagnostic systems provide the detailed measurement of the plasma parameters that are critical to the research goals of NCSX. The project, as currently baselined, is scheduled for completion in July 2009.

The Committee's major recommendations to the project include the following:

- Expedite design engineering and reviews whenever possible,
- Improve the data analyses that form the basis of the baseline estimates,
- Ensure that the full project work scope as approved in the FY 2005 baseline and the new proposed baseline are consistent,
- With new guidance from the Program Office, develop an alternate cost/schedule baseline based on an "optimum" funding profile, and
- Provide strong leadership in the systems engineering and integration area.

There were no action items resulting from the review.

For activities beyond CD-4, PPPL presented a prioritized list of experimental activities to be accomplished to start Phase III (initial heating experiments). The cost to initiate Phase III activities in FY 2013 is $34.4 million. In addition to Phase III, PPPL will perform Phase II (e-beam mapping), R&D, and operations activities from FY 2007 to FY 2013.

CONTENTS

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 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, was obtained 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 initial cost 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 date 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 date. 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 (signed 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, Approve Start of Construction, was obtained 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

2.1 Accomplishments to Date

The NCSX accomplishments, to date, include:

- Of the 18 modular coils, 14 have completed winding operations through Vacuum Pressure Impregnation (VPI) and warm testing. The remaining coils are in various stages of fabrication. All 18 Modular Coil Winding Forms (MCWF) were delivered.
- The first of the 18 Toroidal Field (TF) coils was fabricated and delivered with no outstanding technical issues to address.
- All three of the Vacuum Vessel Sub-Assemblies (VVSAs) were fabricated and are being fitted with access ports, cooling coils, and diagnostics.
- Prototype assembly operations were initiated and are ongoing.
- Work on ancillary systems is proceeding at an appropriate pace.

2.2 Magnets

2.2.1 Findings

The magnets subsystems include modular coils and conventional coils. The modular coils consist of 18 precision machined winding forms, wound copper conductor, and the modular coil interface hardware. The conventional coils include 18 toroidal field coils, six poloidal field (PF) coils, a central solenoid, and two trim coils.

All the MCWFs were fabricated and delivered from Energy Industries of Ohio (EIO) to PPPL by June 1, 2007. Fourteen modular coils were wound and have completed VPI with epoxy. The coils have met the strict +/- 0.5 mm tolerance on current center position and have passed electrical testing. Operations have gone smoothly, with no major issues for over a year. The estimate for completing the modular coils was based upon a detailed task breakdown and actual in-field times to complete the coils. This can be expected to provide a very good basis for the cost and schedule estimates.

The 18 modular coils must be joined together to form a stiff shell structure to react to the loads. The coils are bolted on the outside, but on the inside there is no room for fasteners. The conceptual design concept relied principally on shim friction to take the shear load, but detailed analysis showed that this was not likely to be adequate. The project has been exploring different options for the last year. They have recently developed an approach that appears likely to be satisfactory. The solution is to weld the shims in the inboard region on the mid-field period joints that make up a field period assembly. Where the three field periods meet the joint is still based on friction, but with additional bolted connections above and below the nose region. Shims with an alumina coating were developed that show a large safety factor for the measured versus required coefficient of friction for this design. Weld testing was started and the preliminary results are encouraging with acceptable magnetic permeability. Low distortion must still be demonstrated for the castings. This verification is included in the third phase of a three-phase program and is expected to be completed in September.

As of this review, the modular coils WBS, which included the modular coils and the design of the interface hardware had an Actual Cost of Work Performed (ACWP) of $34.2 million with an Estimate at Completion (EAC) of $40.4 million.

The 18 TF coils, including the wedge castings, are being fabricated under a fixed-price subcontract with Everson-Tesla, Inc. The first coil is complete and the next three coils are due by the end of September. The technical requirements are being met. Process development for the first coil took longer than expected. Tolerance control, the inflexibility of the solid copper conducter, and metrology are the cost and schedule drivers. The new project schedule has incorporated the experience on the first coils and the last coil delivery is expected in September 2008, which is more than one year off the critical path.

The PF coil system consists of a symmetrical array of three coils above the midplane and three coils below. All coils use conventional rectangular copper conductor and are round with rectangular cross sections and no steel case. The preliminary design review (PDR) is scheduled in December 2007 and there is a Level 2 milestone in March 2008 to complete the PDR. Two vendor budgetary estimates were obtained for the conceptual designs and the higher estimate used. Spare copper for one additional coil was included in the estimate to mitigate the risk of a fabrication failure. A contingency plan was developed for in-house fabrication in case no bids are received.

The design for the trim coils was scheduled for later in the project with a Final Design Review (FDR) in December 2008. The cost estimate is based on two 40-inch diameter coils. They are expected to be two turn coils using the PF coil conductor and mounted directly to the MCWFs. The present design for the central solenoid uses an available spare magnet from National Spherical Torus Experiment (NSTX). No significant design or fabrication effort is expected to be needed.

As of this review, the conventional coil's WBS had an ACWP of $3.2 million with an EAC of $6.7 million.

2.2.2 Comments

There now appears to be enough engineering support to eliminate or minimize concurrent engineering that seems to have been a problem in the past.

The cost estimates for the work to go appear to have a good basis, particularly for the modular coils. The modular coil interface design was a difficult problem, but the recently developed approach appears to be very promising. The project has made this effort a high priority and has applied adequate resources to develop the solution in a timely manner.

The use of only two trim coils may limit the ability to correct field errors discovered during final machine assembly. There may also be cost trade-off between acceptable tolerances and the use of additional trim coils for corrections.

2.2.3 Recommendations

1. Accelerate specific engineering efforts such as the PF design. This would help to provide better cost estimates and reduce schedule risk. As an example, if in-house fabrication was found to be needed or if production problems were encountered during fabrication, discovering this earlier would reduce the schedule impact. Also, having final designs earlier would allow a better definition of the tasks needed for field period and final machine assembly.

2. Perform a cost/benefit analysis of fabricating and installing the full complement of trim coils. There may be an advantage to wind additional coils after the first two while the winding line is in place and personnel have experience. It may also be

possible to increase the acceptance for out-of-tolerance conditions if additional trim coils are available.

2.3 Ancillary Systems

2.3.1 Findings and Comments

Ancillary Systems (WBS 2) covers a number of elements that make up the conventional systems and utilities in support of the NCSX in operation and controls. These are all familiar systems to the assigned cognizant job mangers, all with many years experience in the design and installation of similar equipment at PPPL. The resource-loaded schedules for these elements appeared complete for a basis of estimate that was satisfactory.

Fueling and Vacuum Pumping Systems were reduced by $194K by using a lower capacity existing turbo molecular vacuum pumping system that may meet pressure requirements at half the pumping speed. The schedule for start of design is planned for FY 2009 and it is not on the critical path. The cost of this system was found to be reasonable based on known equipment. The project's EAC with contingency for this element is $625K.

Diagnostics Systems (WBS 3) includes both Magnetic Diagnostic Systems and Electron Beam Mapping. The magnetic sensors include design, fabrication, and installation of diamagnetic loops, flux loops, saddle loops, Rogowski coils and B-coils that will provide magnetic flux feed-back to determine field geometry. Designs of the loops are complete with 60 percent installed and not on critical path. Cost of this element has increased by $590K. The initial baseline design was inadequate and found to be more difficult than originally expected due to requirements for insulation and component protection. E-beam mapping consists of equipment required in the field line mapping phase of operations. The cost has decreased by $62K, taking advantage of equipment loans and collaboration arrangements. The project's EAC with contingency for this element is $1,759K.

Electrical Power Systems (WBS 4) includes AC and DC Power Systems, Controls and Protection Systems, Systems Design and Integration. The existing AC power infrastructure at NCSX C-site will be refurbished as required along with system grounding. For DC power refurbishment of existing cables, rectifiers and components are included. This includes the design, fabrication, and installation of an electrical controls interlock system to ensure proper configuration of power systems during operation. The schedule calls for the start of system design in FY 2009 and it is not on critical path. The cost of this element was reduced by $156K to meet minimum CD-4 requirements, which were reductions in controls and the number of circuits. The costs are well understood based on refurbishment of existing systems at PPPL. The project's EAC with contingency for this element is $3,530K.

Interface and Control Systems (WBS 5) includes Networking Infrastructure, Central Interface and Control Systems, DAQ and Facility Computing, Facility Timing and Synchronization Systems, Power Supply Control Systems, Safety Interlocks and System Integration. The schedule calls for start of system design in FY 2009 and it is not on the critical path. The cost of this element was reduced by $881K to meet minimum requirements to satisfy CD-4 objectives. These systems costs are well understood based on similar system design and installation. The project's EAC with contingency for this element is $1,332K.

Facility Systems (WBS 6) includes Cryogenic Systems for delivery of LN2 for coil cooling systems and the GN2 cryostat cooling system for distribution through NCSX during operations. The schedule calls for the start of system design in FY 2009 and it is not on critical path. The cost of this portion of the element has increased by $192K from design experience gained in the operations of the coil test facility system. These are well understood costs based on comparable system design and installation. This element also includes Vacuum Bake-out Systems in support of high temperature bake-out of vessel and control of vacuum vessel heat loading in operation. The schedule calls for start of design in FY 2009 and it is not on the critical path. The cost of this portion of the element has increased by $573K; the original induction heating system design was eliminated along with its cost. A known 150-C Gas Bake-Out system will be installed instead to achieve adequate CD-4 vacuum requirements. The system costs are well understood from similar designs. The project's EAC with contingency for this element is $1,784K.

2.3.2 Recommendations

1. Although these elements have planned design starts in FY 2009 due to a flat budget profile, it was recommended that early conceptual design modeling be started with preliminary design reviews immediately following to catch any technical issues early in the design process.

2. The Safety Interlocks System should be reviewed, as early as possible, with the ES&H group to resolve any life safety and equipment protection issues or requirements.

3. Further study the cryogenic system and GN2 system design for control and regulation of gas through multiple parallel paths.

2.4 Final Machine Assembly

2.4.1 Findings

According to the re-baseline totals, WBS 18 has spent $3,479K out of $13,583K (26 percent) and WBS 7 has spent $963K out of $8,914K (11 percent).

The Estimate to Complete (ETC) for field period assembly (WBS 18) in the proposed re-baseline is now calculated to be $10,104K with overall contingency assignment of 30 percent ($3,013K). The ETC for Test Cell Prep and Machine Assembly (WBS 7) in the proposed re-baseline is now calculated to be $7,951K with overall contingency assignment of 38 percent ($3,036K). Together these make up roughly 42 percent of the full project ETC contingency and are the two highest contingency values, as well as the two highest individual ETC values.

The cost estimates listed in 3.3.1.1 reflect increases of $8,143K or 250 percent (WBS 18) and $4,501 or 202 percent (WBS 7) from the 2005 baseline figures.

Increases in WBS 18 are attributed to underestimation of engineering and labor costs associated with assembly of complex, tight tolerance, massive components including cost of extensive metrology and field engineering required to custom fit modular coils together.

Increases in WBS 7 are attributed to applying lessons learned during modular coil fabrication (WBS 14) and early stages of field period assembly (WBS 18) to estimates of labor and tooling required.

Inter-modular coil connection hardware and methods design costs are captured in WBS 14 (Modular Coils) although they are procured, fabricated, utilized, and field engineered in WBS 18 and WBS 7.

Solutions to the technical problems presented by the modular coil inter-connections were identified and are in the process of being verified. Welded shims are the most promising solution to the inner connection area (“nose”). Alumina coated (high friction and electrical insulation) shims are the most promising solution to the outer connection areas. Several tests were conducted utilizing external consultants (Edison Welding Institute) and more are ongoing to validate the design solutions.

The re-baseline proposal shows remaining design effort for field period assembly and final machine assembly activities (including drawings and specifications) as 4,692 plus 1,896 (from WBS 1803) hours with design activities for final machine assembly completing October 2008. Design team work will continue through actual field period assembly and final machine assembly ("back-office" field engineering, Title III) totaling 2,954 hours (field period assembly) through November 2009 and 2,505 hours (final machine assembly) through January 2011.

Detailed and comprehensive plans for field period assembly were presented. Conceptual plans for final machine assembly were presented. All plans incorporated metrology and functional step detail for further development into technical procedures.

Various modular coil interface designs were listed as passing five FDRs between June 29, 2007 and August 7, 2007 with three more planned (last one in January 2008). Recent review activity (since January 1, 2007) for field period assembly is listed as one FDR on July 17, 2007 for Station 3 Tooling. Future field period assembly reviews are planned for November 27, 2007 (Station 5) and June 4, 2008 (Station 6 (actually final machine assembly, WBS 7)). Design reviewers consist of PPPL and ORNL personnel, not necessarily external to NCSX project.

The project has implemented new tasks into the field period assembly WBS to support "trials" or testing R&D to validate design solutions. The project has "re-vitalized" efforts to design early in the assembly cycle rather than rely on "concurrent" engineering by adding two engineers to both the metrology team and the field engineering support team.

Twelve of the 31 risks registered in the Risk Registry for the project are directly related to modular coil interface, field period assembly, and final machine assembly. Only two are classified as moderate risk (coil interface), the remainder are classified as low risk. Mitigation plans are listed for all risks.

WBS 1416 documentation contained job numbers and titles that were not consistent with other documentation.

Other than those tests currently underway, no further design verification tests are planned for Stations 1-5. Dry-run fit-ups are planned for Stations 2 and 3.

WBS 7501 contains tasks (for testing assembly sleds) for which no Basis of Estimate is shown.

Dry-run fit-ups for Station 6 are in the schedule, but are indicated by the project to be unnecessary if metrology efforts are successful.

Bottoms-up estimates were shown for all tasks, based on a detailed assembly sequence plan. For those tasks lacking sufficient design maturity (Stations 3, 5, and 6), greater allowance was made for unknowns.

Engineering resources at ORNL and PPPL were shown to be currently adequate for the re-baselined tasks. In addition, the Committee found emphatic support at the Directorate level to add any necessary engineering effort.

2.4.2 Comments

The project staff should be congratulated on the significant engineering, design, and technical effort over the past months to overcome technical problems and develop detailed assembly plans and equipment. The engineering staff developed engineering solutions for recent problems in field period assembly that have a high probability of success. The Committee did not identify any other technical "show-stoppers" that threaten the completion of field period assembly or final machine assembly.

The Field Period Construction Manager should be commended for his effort to anticipate and mitigate rigging, measurement and positional tolerance problems prior to actual assembly and in the absence of detailed drawings.

The level of detail in the field period assembly plan and procedures is very commendable and coupled with the detailed three dimensional CAD modeling, provided a relatively firm basis for the present schedule and cost estimate.

Basis of estimate documentation, in general, validate the cost and schedule estimates. In some areas, basis of estimate documentation was either non-existent or non-traceable. However, overall the Committee found the cost estimates and schedule estimates credible, including enough money to ensure success in a realistic environment. Contingency/risk assignment is consistent with the levels of design and status of assembly tasks. The work to develop the assembly plans is commendable and translating those into detailed procedures should be achievable.

Integration of design activities across WBS tasks is not ideal. Design of connection and support hardware is split across at least two WBS's (14 and 7). In addition assembly tooling design is captured in another WBS (18). Careful integration of these activities at an early stage is necessary for success in field period assembly and final machine assembly in the long term. In addition, recent Preliminary Design Reviews and FDRs do not seem to successfully integrate these designs and interface features as they are now. Management of engineering resources, integration of engineering design activities across WBS tasks, and design review scope and scheduling is considered to be crucial to the assembly tasks. Proper resources should be focused upon this task.

Vacuum vessel welding (in Station 6) seems to be underestimated in terms of technical risk. Distortion during these difficult welds should be assessed and mitigation efforts identified.

2.4.3 Recommendations

1. Scrub the resource-loaded schedule, work approval forms, and basis of estimate documentation for accuracy traceability and completeness.

2. Consider accelerating the schedule of Preliminary Design Reviews and FDRs to encourage early design activity and solidify estimates.

3. Include objective experts external to the project, and within the primary laboratories, on design review teams.

4. All integration issues associated with related assembly tasks should be included in design reviews. Add vacuum vessel welding (in Station 6, Final Assembly) to the Risk Registry and develop appropriate mitigation activities.

5. Continue to include dry-run fit-ups of the final machine assembly of modular coils in the resource-loaded schedule, and plan to perform these tasks even if metrology results appear to "close" properly.

6. Continue to look for opportunities to validate assembly design concepts early in the

design process.

7. Ensure that engineering integration across WBS tasks occurs at a high level including interface design consistency, definition, and scheduling of design reviews, and engineering resource management. This will require the focus of the responsible engineer as his/her primary activity.

2.5 Phase III and IV Scope

2.5.1 Findings

The project presented a prioritized list of experimental activities to be accomplished in the Phase III campaign for FY 2013. These activities have been endorsed by the NCSX Physics Advisory Committee (PAC).

The goals represent important scientific achievements in understanding the potential of quasisymmetry on global confinement in hot-ion plasmas, initial investigations into the role of stellarator fields in disruption prevention, and obtaining knowledge of scrape-off layer characteristics necessary for upgrades required for Phase IV activities.

The facility and diagnostic upgrades presented covered all necessary scope to accomplish these goals.

The planning level budget of $34.4 million appears adequate to cover the needed costs.

The schedule appears reasonable providing the needed facilities at the appropriate time for Phase III activities, with a funding profile that takes into account longer lead time articles such as neutral beam refurbishment and Thomson scattering.

2.5.2 Comments

The cost and schedule estimates were developed taking into account resource-loading and a funding profile consistent with roll-off of the MIE, and which keeps total NCSX program costs level until FY 2013.

The upgrade plans include capabilities in some elements that are required for progressing to Phase IV of the research (such as power systems), and $4.5 million in FY 2013 for long-lead items for the FY 2015 campaign, such as neutral beam units #3 and #4.

A significant portion of the upgrades are refurbishments of existing equipment, duplication of previously produced systems, or routine in nature resulting in estimates that are on a very sound basis for a planning level. The development of a resource-loaded schedule with detailed cost breakouts and a 30 percent overall contingency provide confidence in these estimates and schedules.

Funds are planned to start becoming available in FY 2010 for these activities. The project should reinvestigate the need, priorities, cost, and schedule for the various planned upgrades as this period approaches, commensurate with research forums that will be occurring. Roughly one-third of the research is planned to be conducted through collaborations and this needs to be factored into the planning process.

2.5.3 Recommendations

1. Investigate the cost and benefit of inclusion of four additional trim coils into the upgrade plans. Present plans will augment the two coils in the MIE with two additional coils, so that n=1 and n=2 fields can be applied. The addition of two more would provide for control over natural (n=3) islands.

2. Coordinate cost and schedule planning between NCSX and NSTX. In FY 2013, a $25 million increase in the NCSX program total occurs as NCSX goes into Phase III operation and the two devices go to alternate year operations. The total available funds must be commensurate with NCSX operations and NSTX station-keeping and upgrade costs, and the reverse in the alternate years, and with the total OFES funding for the two devices.

Intentionally Blank

3. COST ESTIMATE

3.1 Findings

The NCSX project team presented a proposed Estimate to Complete (ETC) of $67.2 million (as of May 1, 2007) that includes contingency of $14.4 million or 28.3 percent of the ETC. The ETC is an unconstrained bottoms-up estimate based on estimates developed by individual Job Managers over several months using guidelines established by the project. These estimates were independently reviewed for realism and consistency by PPPL's Head of Engineering and Technical Infrastructure.

While not presented as a formal baseline change proposal, the newly developed ETC, when combined with actual costs through the end of April 2007, results in a revised TPC of $142.0 million (TEC = $131.4 million; OPC = $9.6 million).

The project's contingency estimate was based on detailed, probabilistic risk and uncertainty analyses. The final contingency value, while based on the outcome of the risk and uncertainty analyses, was adjusted upward based on the project manager's experience to account for unknown unknowns.

3.2 Comments

The methodology underpinning the project's proposed bottoms-up ETC adds credibility to the proposed baseline. The ETC is based on a well-defined estimating methodology involving all Job Managers. The ETC incorporates experience and lessons learned on the project to date. Using an independent review of the estimate by the head of engineering has clearly added value (ensuring realism and consistency) to the overall process. In addition, Princeton University commissioned its own independent review committee, which endorsed the project estimates.

The project's new probabilistic risk and uncertainty analyses are based on the new bottoms-up cost estimate. The rigor and understanding imparted to the project by this new process provides a sound basis for the proposed amount of contingency.

While the overall basis of estimate is sound, additional work will be needed to improve documentation and traceability to readily facilitate external reviews.

3.3 Recommendations

1. Institutionalize the new cost estimating methods and tools (ongoing).

2. Improve the documentation and traceability of the basis of estimate (well before the External Independent Review).

3. Ensure the machine capabilities in the FY 2005 baseline and the new proposed baseline are consistent.

4. SCHEDULE and FUNDING

4.1 Findings

The NCSX project presented a proposed project completion date of December 2011, including 11 months or 24 percent of schedule contingency. The proposed new CD-4 date extends the schedule by 29 months. The resource-loaded schedule was developed using a bottoms-up approach (at WBS Level 4 or lower) with input from Job Managers on resources needed, duration of activities, and potential risks and uncertainties associated with the activities. The resource-loaded schedule is integrated and identifies critical path or near critical path activities.

Similar to the cost contingency, the schedule contingency was based on detailed, probabilistic risk and uncertainty analyses. In addition to a revised schedule, the project has identified and updated a significant number of new Level 2 and 3 milestones to enhance identification of deliverables and management tracking.

The proposed funding profile presented by the project is shown in Table 4-1. It should be noted that this funding profile does not lead to optimized cost, schedule, and contingency baselines for project completion.

Table 4-1. NCSX Proposed Funding Profile

	Prior FY ($K)	FY2006 ($K)	FY2007 ($K)	FY2008 ($K)	FY2009 ($K)	FY2010 ($K)	FY2011 ($K)	Total ($K)
Budget Authority	$38,388	$19,073	$15,838	$14,483	$15,068	$12,581	$2,602	$118,033
Contingency			$144	$2,205	$3,492	$4,450	$4,089	$14,380
TEC (MIE)	$38,388	$19,073	$15,982	$16,688	$18,560	$17,031	$6,691	$132,413
OPC	$9,600							$9,600
TPC	$47,988	$19,073	$15,982	$16,688	$18,560	$17,031	$6,691	**$142,013**

4.2 Comments

The project has a good process for developing and updating the resource-loaded schedule. However, documentation on some of the WBS elements (i.e., basis of estimates, assumptions, etc.) needs to be improved.

Generally, the project meets the External Independent Review lines of inquiry related to a baseline deviation and the Committee believes the project can be completed within the schedule presented.

4.3 Recommendation

1. Improve the basis of estimate—improved quality of bases of estimates (well before the EIR).

5. MANAGEMENT

5.1 Findings

A new Project Manager, with extensive DOE project experience, was brought on board by Princeton University in early July 2007. He is being funded directly by the University. His assignment is short-term, through approximately January 2008, until a permanent replacement is found. During this short time, he has already had a positive impact on the project. He has instituted new management processes that include more disciplined practices, such as implementing a Risk Register that is updated monthly and requiring a new bottom-ups ETC to be developed semi-annually. PPPL management is actively recruiting for the permanent Project Manager position and identified several qualified candidates.

Senior management of Princeton University, PPPL, and the DOE Princeton Site Office expressed strong support for the NCSX project. All parties appear to be well informed of the project's status and issues.

Over the past several months, the University has greatly intensified its oversight of PPPL in the area of project management. For instance, it sponsored a NCSX Engineering Workshop in May 2007 and a NCSX Project Management Review the following month. The University Dean for Research meets at least weekly with PPPL and NCSX management, and the University's PPPL Operations Oversight Board plans to review NCSX cost and schedule performance on a monthly basis. Lastly, they have proposed to meet monthly with the Office of Science Associate Director for OFES and Director, Office of Project Assessment to discuss NCSX progress, issues, and plans.

A beneficial relationship was recently established between the senior management of the NCSX and Wendelstein-7X (W-7X) stellarator projects to share information about common technical issues and potential solutions. These projects are quite similar in design and are at comparable stages of completion.

The relationship between PPPL and their partner laboratory, ORNL, is generally good and there is good communication at all levels. At this stage, ORNL's effort comprises around ten percent of the NCSX budget.

Likewise, NCSX management and the DOE Princeton Site Office, including the Federal Project Director, are working well together and have common goals for successfully completing the project.

Most hardware procurements were awarded and the vast majority of the major components are on-site at PPPL. The remaining project scope is therefore mostly within the direct control of PPPL, and the largest remaining risks reside in the field period and final machine assemblies. The design in these areas is still at an advanced conceptual level and plans are to finish the design work in 2008.

Overall, PPPL and ORNL appear to have adequate staffing, especially engineering resources, to complete the project scope. In a few important areas, however, the project does not seem to have sufficient depth, which PPPL management recognized and is attempting to address through cross training and recruitment. It was noted that two key PPPL staff, a cryo engineer and a senior systems engineer, are being hired away to work elsewhere. Most of ORNL's staff on NCSX are only part-time.

Field period and final machine assemblies activities involve a great deal of hoisting and rigging operations that demand a high degree of precision and care to avoid damage to major components (modular coils and VVSA). PPPL and the project appear to have good procedures in place and have appropriately emphasized their importance. Ample attention is being devoted to Integrated Safety Management.

At present, the project's EVMS is not producing useful information to aid NCSX management because it is referencing the approved baseline cost and schedule estimates rather than the proposed new baseline cost and schedule. The NCSX project began informal tracking against the proposed baselines over the past three months with favorable results.

The flat funding guidance from OFES that has served as the basis for the project's ETC is not as efficient as an optimized funding profile. This project has had a flat funding profile for most of its existence, which has led to deferral of non-critical path work such as field period and final machine assemblies design where significant difficulties were encountered.

Within the project funding profile, contingency is somewhat back-end loaded, and it is not clear that the contingency distribution by year is tied to when corresponding risks are likely to occur and when contingency would be needed.

Since the project's inception, OFES has been funding ORNL directly rather than putting all project funds at PPPL for them to manage and distribute to ORNL via an Inter-DOE Work Order (IWO). This approach requires OFES to make Financial Plan adjustments to implement any changes in ORNL's work scope that NCSX management at PPPL might deem necessary. This process typically injects a two-month lag between the time NCSX management decides to change ORNL tasking until ORNL receives the funds to implement it.

5.2 Comments

The new Project Manager, now teamed with his technically strong predecessor, provides a better overall capability to run the project and keep on top of the technical issues.

The loss of the senior systems engineer will leave a void in the NCSX organization, and there will be an acute need for a qualified and experienced person to serve as a Chief Engineer who can perform systems integration and engineering.

The NCSX project is under extreme scrutiny. The permanent NCSX Project Manager will need to ensure that oversight by DOE, PPPL, and Princeton University does not interfere with timely decision making to keep the project on schedule.

The NCSX Project Execution Plan should be reviewed to ensure that it reflects the steps taken to strengthen project management oversight and processes.

Completion of field period and final machine assemblies design work should be accelerated if at all possible. Because this part of the design was deferred until late in the project due to annual funding limitations, NCSX management did not fully appreciate the complexities of field period and final machine assemblies that have largely contributed to the recent growth in cost and slippage in schedule. This strongly argues in favor of optimizing what remains of the project budget authority (BA) profile during FY 2008 through FY 2011. Moving BA into FY 2008 would also permit a more realistic distribution of contingency over the remaining schedule.

The arrangement for funding PPPL and ORNL separately is different from other SC projects, and serves no clear purpose. OFES holds PPPL accountable for the entire project, and the laboratory should therefore have direct control over all project funds.

Until a new cost/schedule baseline is formally adopted, the Federal project Director and NCSX management should evaluate performance against the proposed baseline. Naturally, the data entered into the DOE Performance Assessment and Reporting System (PARS) will have to be compared with the existing approved cost/schedule baseline.

5.3 Recommendations

1. Evaluate and quantify the cost and schedule benefits of optimizing the remaining budget authority profile by September 15, 2007.

2. Provide a plan for ensuring strong leadership in the systems engineering and integration area as soon as possible.

APPENDIX A

CHARGE MEMORANDUM

Department of Energy
Washington, D.C. 20585

July 19, 2007

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

FROM: Raymond Fonck
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 latest cost and schedule performance, and the project's path forward. This information will help SC determine whether the remainder of the NCSX Project's scope, cost and schedule are reasonable.

The review is planned to be held on August 15-17, 2007, at PPPL. In carrying out its charge, the review committee should evaluate the following:

1. Is the project's bottoms-up-estimate credible? Based on the funding guidance provided by the FES Program, is the cost and schedule estimate realistic for the remaining work? Is there an adequately mature design available on complex activities, such as machine assembly, to support the estimate?

2. Is the contingency supported by and consistent with an appropriate project-wide risk analysis? Is there adequate cost and schedule contingency in the new proposed baseline to achieve a high level of confidence in completing the project successfully?

3. Has the Project adequately incorporated developmental and fabrication experiences in the bottoms-up estimate as to increase the success of machine assembly and improve reliability during research operations?

4. Is the project being properly managed and organized at this point, and are future staffing plans at both PPPL and ORNL adequate? What is the level of confidence that the NCSX

project team can complete the project within the proposed baseline? Is there adequate support from PPPL and ORNL management?

5. What is the planning level cost and schedule estimate that will be required for the NCSX project to perform Phase III (which includes implementation of all scope that was removed after CD 2) research activities?

Barry Sullivan, the 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 15 days of the conclusion of the review. This review will play an important role in ensuring that the NCSX project can be completed within the cost and schedule that they are proposing.

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:
A. Byon-Wagner, SC 2
R. Fonck, SC 24
G. Nardella, SC-24.2
B. Sullivan, SC-24.2
J. Faul, SC-PSO
J. Makiel, SC-PSO
R. Goldston, PPPL

APPENDIX B

REVIEW PARTICIPANTS

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

REVIEW COMMITTEE PARTICIPANTS

Department of Energy

Daniel R. Lehman, DOE/SC, Chairperson
Kin Chao, DOE/SC
Jeff Hoy, DOE/SC
Stephen Meador, DOE/SC
Bruce Strauss, DOE/SC

Consultants

Dave Anderson, U. of Wisconsin
Ralph Brown, BNL
Patrick Hurh, Fermilab
Thomas McManamy, ORNL
Les Price, consultant
Russell Wells, LBNL

Observers

Ray Fonck, DOE/SC
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

Wednesday, August 15, 2007—Lyman Spitzer Building, Room 318

8:00 am	DOE Executive Session	D. Lehman
9:00 am	Princeton University Perspective	S. Smith
9:10 am	PPPL Perspective	R. Goldston
9:30 am	Project Overview and Management	J. Anderson
10:00 am	ORNL Management and Staffing Overview	J. Lyon
10:20 am	Break	
10:30 am	Technical Overview	H. Neilson
11:00 am	Cost and Schedule Baseline Change Overview	R. Strykowsky
11:45 am	Lunch	
12:30 pm	Tour of NCSX Manufacturing Facility	Project Team
1:30 pm	Stellarator Core Design	B. Nelson
2:10 pm	Development and Testing of MC Interface	P. Heitzenroeder
2:45 pm	Break	
3:00 pm	Assembly Sequence Plan	T. Brown
3:30 pm	field period assembly	M. Viola
4:15 pm	final machine assembly	E. Perry
4:45 pm	Discussion	
5:00 pm	DOE Executive Session	D. Lehman
6:00 pm	Feedback/Questions to the Project Team	
6:30 pm	Adjourn	

Thursday, August 16, 2007

8:30 am	**Technical Breakout Sessions (see attached breakout agenda)** **Cost, Schedule, Mgmt. Breakout Sessions (see attached breakout agenda)**
12:00 pm	Lunch—**LSB-318**
1:00 pm	Breakout Sessions Continue
3:00 pm	DOE Executive Sessions—**LSB-318**

Friday, August 17, 2007

8:00 am	DOE Executive Session/Report Writing
9:00 am	Closeout Dry-Run
11:00 am	Closeout (video conference with OFES)
12:00 pm	Adjourn

APPENDIX D

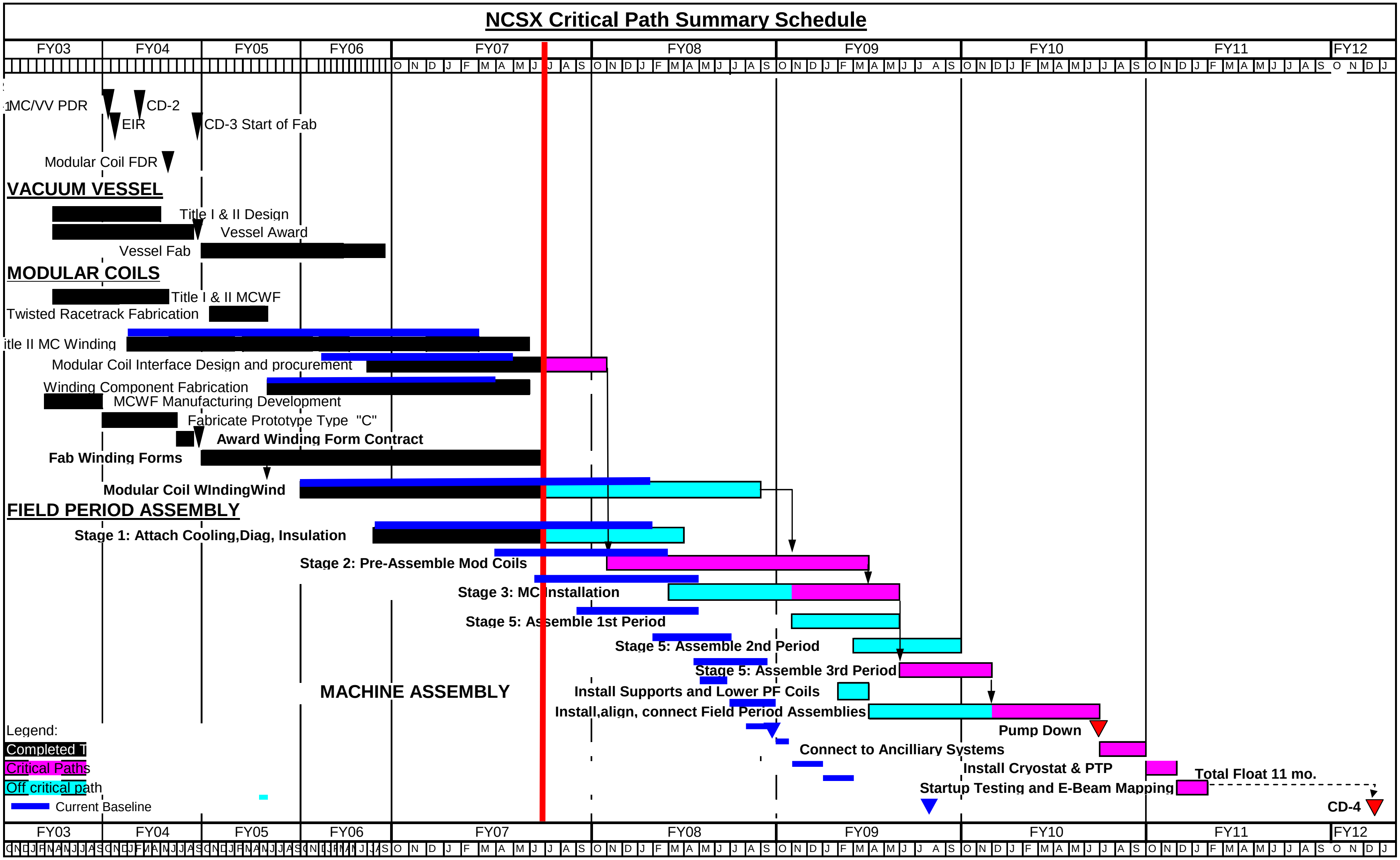
COST
TABLE

				PROJECT ESTIMATE									
					Allocation of Contingency Allowances								
	WBS	Baseline (ECP-31 DOE Directed re-baseline April 2005)	ACWP (Through 4/30/07)	ETC	Uncertainty	Schedule	Sched Mitig	Risk	Management Increment ("unknown unknowns")	Total	% of ETC	TOTAL EAC with contingency	Increase explanation
12	Vacuum Vessel	$9,531	**$9,753**	**$156**	*$30*			*$10*		**$40**	**26%**	**$9,949**	*Heating and cooling system re-design*
13	Conventional Coils	$4,790	**$3,226**	**$3,462**	*$527*			*$175*	*$200*	**$902**	**26%**	**$7,590**	*TF coil fabrication $1.5m and PF coil fabrication $0.4m based on vendor quotes.*
14	Modular Coils	$28,091	**$34,196**	**$6,247**	*$1,002*			*$406*	*$200*	**$1,608**	**26%**	**$42,051**	*Design/R&D $3.3m, Winding form fabrication $1.5m, Mod coil winding $6.5m, Coil testing $1.0m*
15	Structures	$1,413	**$335**	**$1,262**	*$173*			*$8*	*$100*	**$281**	**22%**	**$1,878**	*Redesign of concept to cheaper fabrication*
16	Coil Services	$1,140	**$3**	**$861**	*$67*			*$225*	*$100*	**$392**	**46%**	**$1,256**	*Simplification in the electrical & coolant circuit configuration*
17	Cryostat & Base Support Structure	$1,361	**$431**	**$784**	*$112*			*$5*	*$100*	**$217**	**28%**	**$1,432**	*Simpler cryostat based on experience gained with the coil test facility as well as a stationary base support structure*
18	Field Period Assembly	$5,430	**$3,479**	**$10,104**	*$1,645*		*$355*	*$127*	*$885*	**$3,013**	**30%**	**$16,596**	*More mature assy sequence plan as well as a better appreciation of metrology and dimensional control reqmnts.*
19	Stellarator Core Mgmt & Integr	$2,752	**$2,128**	**$1,620**	*$127*	*$179*		*$10*		**$317**	**20%**	**$4,065**	*Title III support of assy, CAD modeling as well as project stretch-out.*
2	Auxiliary Systems	$783	**$348**	**$241**	*$34*			*$2*		**$36**	**15%**	**$625**	*Fueling and vacuum pumping system designs simplified.*
3	Diagnostics	$1,143	**$954**	**$717**	*$84*			*$5*		**$88**	**12%**	**$1,759**	*Fabrication of magnetic diagnostic loops and first plasma imaging/ e-beam mapping equipt.*
4	Electrical Power Systems	$3,301	**$720**	**$2,425**	*$182*			*$53*	*$150*	**$385**	**16%**	**$3,530**	*Cost growth offset by reduction in reqmnts (controls, number of circuits to minimum req'd for CD-4.*
5	I&C Systems	$2,050	**$33**	**$1,136**	*$156*			*$7*		**$163**	**14%**	**$1,332**	*Reqmnts reduced to minimum req'd to satisfy CD-4.*
6	Facility Systems	$691	**$24**	**$1,379**	*$372*			*$9*		**$381**	**28%**	**$1,784**	*Bake-out system added $.6m and cryogenic system cost growth based on experience.*
7	Test Cell Prep & Machine Assy	$4,413	**$963**	**$7,951**	*$2,375*			*$162*	*$500*	**$3,036**	**38%**	**$11,950**	*More mature assy sequence plan as well as a better appreciation of metrology and dimensional control reqmnts.*
81	Project Management	$4,509	**$3,376**	**$4,342**	*$375*	*$1,122*		*$79*		**$1,576**	**36%**	**$9,294**	*Addition of a construction manager, add'l project control staff, as well as project stretch-out cost.*
82	Project Engineering	$4,885	**$5,248**	**$5,948**	*$600*	*$628*				**$1,228**	**21%**	**$12,424**	*Dimensional control planning, support of metrology ops, on on-going CAD modeling,& engineering analysis.*
84	Project Physics	**$470**	**$470**									**$470**	
85	Start-up	**$1,189**		**$765**	*$75*				*$125*	**$200**	**26%**	**$965**	*Test plans streamlined based on NSTX experience.*
89	Allocations	$1,577	**$1,416**	**$1,454**	*$100*	*$417*				**$517**	**36%**	**$3,387**	*Indirect overhead as a function of project stretch-out.*
	dcma	$75	**$75**									**$75**	
	contingency	$12,804											
	Total	**$92,401**	**$67,178**	**$50,854**	*$8,036*	*$2,346*	*$355*	*$1,282*	*$2,360*	**$14,380**	**28.3%**	**$132,411**	

	WBS	DOE Review Estimate			
			Contingency		
		ETC	Total	% of ETC	TOTAL EAC
12	Vacuum Vessel	**$156**	**$40**	26%	$9,949
13	Conventional Coils	**$3,462**	**$902**	26%	$7,590
14	Modular Coils	**$6,247**	**$1,608**	26%	$42,051
15	Structures	**$1,262**	**$281**	22%	$1,878
16	Coil Services	**$861**	**$392**	46%	$1,256
17	Cryostat & Base Support Structure	**$784**	**$217**	28%	$1,432
18	Field Period Assembly	**$10,104**	**$3,013**	30%	$16,596
19	Stellarator Core Mgmt & Integr	**$1,620**	**$317**	20%	$4,065
2	Auxiliary Systems	**$241**	**$36**	15%	$625
3	Diagnostics	**$717**	**$88**	12%	$1,759
4	Electrical Power Systems	**$2,425**	**$385**	16%	$3,530
5	I&C Systems	**$1,136**	**$163**	14%	$1,332
6	Facility Systems	**$1,379**	**$381**	28%	$1,784
7	Test Cell Prep & Machine Assy	**$7,951**	**$3,036**	38%	$11,950
81	Project Management	**$4,342**	**$1,576**	36%	$9,294
82	Project Engineering	**$5,948**	**$1,228**	21%	$12,424
84	Project Physics			#DIV/0!	$470
85	Start-up	**$765**	**$200**	26%	$965
89	Allocations	**$1,454**	**$517**	36%	$3,387
	dcma				$75
	contingency				
	Total	$50,854	**$14,380**	28%	$132,411

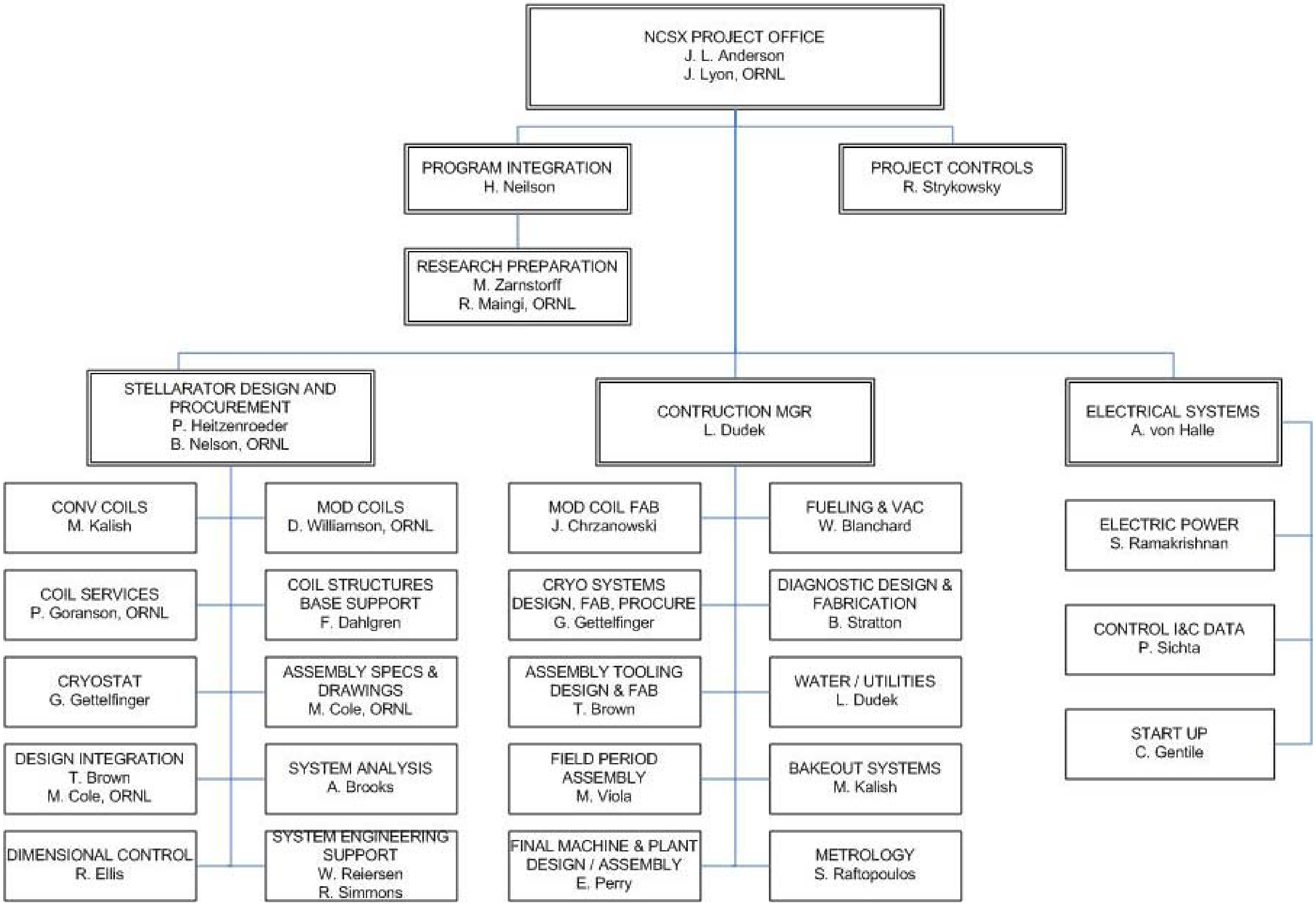
APPENDIX E

SCHEDULE CHART


NCSX Critical Path Summary Schedule
FY03
FY04
FY05
FY06
FY07
FY08
FY09
FY10
FY11
FY12
MC/VV PDR
CD-2
EIR
CD-3 Start of Fab
Modular Coil FDR
VACUUM VESSEL
Title I & II Design
Vessel Award
Vessel Fab
MODULAR COILS
Title I & II MCWF
Twisted Racetrack Fabrication
itle II MC Winding
Modular Coil Interface Design and procurement
Winding Component Fabrication
MCWF Manufacturing Development
Fabricate Prototype Type "C"
Award Winding Form Contract
Fab Winding Forms
Modular Coil WIndingWind
FIELD PERIOD ASSEMBLY
Stage 1: Attach Cooling,Diag, Insulation
Stage 2: Pre-Assemble Mod Coils
Stage 3: MC Installation
Stage 5: Assemble 1st Period
Stage 5: Assemble 2nd Period
Stage 5: 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
Total Float 11 mo.
Startup Testing and E-Beam Mapping
CD-4
Legend:
Completed T
Critical Paths
Off critical path
Current Baseline

APPENDIX F

MANAGEMENT CHART



NCSX PROJECT OFFICE
J. L. Anderson
J. Lyon, ORNL
PROGRAM INTEGRATION
H. Neilson
PROJECT CONTROLS
R. Strykowsky
RESEARCH PREPARATION
M. Zarnstorff
R. Maingi, ORNL
STELLARATOR DESIGN AND PROCUREMENT
P. Heitzenroeder
B. Nelson, ORNL
CONTRUCTION MGR
L. Dudek
ELECTRICAL SYSTEMS
A. von Halle
CONV COILS
M. Kalish
MOD COILS
D. Williamson, ORNL
COIL SERVICES
P. Goranson, ORNL
COIL STRUCTURES BASE SUPPORT
F. Dahlgren
CRYOSTAT
G. Gettelfinger
ASSEMBLY SPECS & DRAWINGS
M. Cole, ORNL
DESIGN INTEGRATION
T. Brown
M. Cole, ORNL
SYSTEM ANALYSIS
A. Brooks
DIMENSIONAL CONTROL
R. Ellis
SYSTEM ENGINEERING SUPPORT
W. Reiersen
R. Simmons
MOD COIL FAB
J. Chrzanowski
FUELING & VAC
W. Blanchard
CRYO SYSTEMS DESIGN, FAB, PROCURE
G. Gettelfinger
DIAGNOSTIC DESIGN & FABRICATION
B. Stratton
ASSEMBLY TOOLING DESIGN & FAB
T. Brown
WATER / UTILITIES
L. Dudek
FIELD PERIOD ASSEMBLY
M. Viola
BAKEOUT SYSTEMS
M. Kalish
FINAL MACHINE & PLANT DESIGN / ASSEMBLY
E. Perry
METROLOGY
S. Raftopoulos
ELECTRIC POWER
S. Ramakrishnan
CONTROL I&C DATA
P. Sichta
START UP
C. Gentile

APPENDIX G

EIR
LINES OF INQUIRY

EIR Lines of Inquiry for the NCSX Project

1. Resource Loaded Schedule—Satisfactory

PPPL Response: The project's baseline change proposal is supported by a resource-loaded schedule which is:

- Organized by WBS (refer to WBS and WBS Dictionary)
- Resource estimate based on detail WAF packages signed by job managers.
- Estimates based on prior experience, vendor quotes, fabrication estimates, design calculations.
- Task durations based on realistic manpower loadings and crew sizes (see WAF packages for WBS 18 and 75). Balance of task durations based on reasonable loadings (see Primavera resource utilization units per day).
- Schedule detail commensurate with schedule criticality (e.g., WBS 18, Job 1810-minimum task duration one day).

Committee Response: The Committee agreed with the project response for the FPA and Machine Assembly portions of the project.

2. Key Project Cost and Schedule Assumptions—Satisfactory

PPPL Response:

- Standard 8 hour/day, 5 day/week work assumed except where two-shift operations called out in resource-loaded schedule.
- Institutional overhead and labor rates utilized.
- Contingency quantified based on estimate uncertainty and risk using Monte Carlo simulation plus a subjective increment based on project management experience.
- Contingency distributed annually consistent with needs.

Committee Response: The Committee agreed that the schedule estimates are reasonable. The cost and schedule contingency are adequate given design maturity.

3. Critical Path—Satisfactory

PPPL Response:

- Critical path is well defined.
- The schedule is an integrated resource-loaded schedule, developed from the bottoms-up based on cost account manager estimates.

Committee Response: The Committee agreed that the critical path is rational and consistent with the resource-loaded schedule.

4. Funding Profile—Satisfactory

PPPL Response:

- The required BA profile was rigorously derived from the resource-loaded schedule.
- The required BA profile is consistent with the funding profile.

Committee Response: The funding profile is consistent with the resource-loaded schedule.

5. Work Breakdown Structure (WBS)—Satisfactory

PPPL Response:

- The WBS provides a reasonable breakdown of all work in the NCSX MIE project.
- The estimates and resource-loaded schedule are developed and organized based on the WBS and are consistent.

Committee Response: The WBS is reasonable and captures all project work. The resource-loaded schedule is consistent with the project WBS.

6. Risk Management—Satisfactory

PPPL Response: The project has systematically identified risks associated with the work remaining and compiled them in a risk register. Brainstorming sessions, as well as input from individual job managers were used to identify the risks. The likelihood and consequences of each risk have been assessed and risks classified as high, medium, and low accordingly. Potential cost and schedule impacts were quantified and used as input to the contingency analysis. Mitigation plans have been developed where appropriate, and incorporated in the baseline. Risks and mitigation plans for each job are also documented in the Work Authorization Forms which were reviewed by the project and the PPPL Engineering Department and incorporated in the project baseline. Cost and schedule contingency requirements appropriate for these risks were determined probabilistically and included in the project baseline.

Committee Response: Risks were identified, classified, and reflected in the contingency analysis.

7. Basis of Design—Satisfactory with Comment

PPPL Response: The stellarator core system design is quite mature. Final design has been completed and component drawings have been released for fabrication for the vacuum vessel, modular coil, and TF coils. The coils structures are in final design. PF coils and the base support structure are in preliminary design with Preliminary Design Reviews (PDRs) scheduled for late in 2007. No technical risks have been identified for these stellarator core systems which are still in preliminary design. Drawings, specifications, and design review records are on file and can be made available for review. A detailed assembly sequence plan has been drafted which provided a sound, technical basis for the field period and final assembly activities in the projected baseline.

At the current stage of NCSX design, no safety class or safety significant SSC's have been identified. The NCSX PHA noted that excessive leakage of nitrogen gas from the cryostat represents a possible mechanism for oxygen depletion in the vicinity of the cryostat, and identified relevant hazard controls. As the cryostat design continues to develop, this conclusion will be reviewed and altered if necessary.

Committee Response: Adequate for most of project. Some areas still lacking definitive designs. The Committee also felt that the design reviews for remaining work should be accelerated.

16. Integrated Project Team (IPT)—Satisfactory

PPPL Response:

- The Integrated Project Team (IPT) is staffed and functioning in accordance with DOE Order 413.3A. The IPT membership encompasses all appropriate disciplines (DOE project and program management, Laboratory project and program management, ES&H, quality assurance, procurement). The IPT meets every three weeks, chaired by the FPD. Meeting minutes are posted on the project web site.
- New Laboratory project manager is on board. Previous project manager continues with the project, providing continuity on technical issues.
- Project control staff at PPPL and ORNL has been expanded to improve resource planning; tracking of costs, schedules, and risks; and reporting.
- A construction manager is budgeted.
- The Laboratory team organization has been modified to better support the construction phase of the project.
- New management processes have been implemented by the Laboratory team (weekly coordination meetings, internal reporting and reviews, risk management).
- PPPL and ORNL are able to meet the staffing requirements of the project.

Committee Response: In general, adequate staffing is available. Sufficient depth exists at PPPL and ORNL to handle additional needs.