Summary of NCSX Response to Recommendations from the May, 2002, Conceptual Design Review

October, 2003
(rev. 1, November, 2003)

Introduction

A Conceptual Design Review (CDR) of NCSX was held in May, 2002. The CDR panel report contained 28 distinct recommendations addressing issues of design, planning, and management. Several of these were resolved shortly after the CDR, the remainder were folded into the project's work plans and have been addressed in preparation for the October, 2003, Preliminary Design Review. This document summarizes the status of each of the CDR recommendations. All have been addressed at least to the degree required to evaluate cost and schedule implications for the project baseline.

Rev. 1: UTIL-2 response was updated. All issues are now closed.

Recommendation PHY-1. Start-up scenarios with 3 MW NBI

Responsibility: Physics Program, M. Zarnstorff

CDR Panel Report: Develop start-up scenarios with 3 MW neutral beam power.

Project Response: This will be done as part of the research program for developing plasma control strategies and algorithms. It is a long term activity outside the MIE project scope and not a prerequisite for any MIE work scope.

Project's recommended disposition: Closed. Continue as a program task outside of MIE scope, as funds permit.

Recommendation PHY-2. Physics Impact of Magnetic Field Errors

Project Responsibility: WBS 84, M. Zarnstorff

CDR Panel Report: Determine the physics impact of magnetic field error likely to occur from coil imperfections.

Project Response: This has been addressed by assessing the physics properties of a subset of the perturbations from the CDR coil tolerance study, applied to the reference coil set. Since the readily available physics assessment codes all assume stellarator symmetry, only symmetric perturbations were assessed.

Status:
Physics Properties. Several coil perturbations, characterized by different combinations of poloidal and toroidal mode number, have been examined. The perturbation amplitude had to be increased to 1 cm, much larger than required tolerance, to see any effect. The quasi-axisymmetry measure, ϵ_{eff}, did not degrade for any of the three applied coil perturbations. Infinite-n ballooning modes were effectively unchanged. Kink modes were destabilized for the m=1, n=0 and m=6, n=3 cases. Such destabilization is not unexpected since the S3 configuration with the given coil currents was developed as a marginally stable state. The question is what change in the coil currents is necessary to stabilize the kink instability while maintaining good quasi-axisymmetry. For the STELLOPT optimizer was run for the m=1, n=0 and m=6, n=3 cases targeting the essential physics measures. The result is that extremely small coil current changes (<5kA-t for any coil) are necessary.

Magnetic Surfaces. The effect of coil perturbations on island width was initially estimated using a linearized, analytic model that neglected any effects of plasma response. This was reported at the CDR. Since the CDR, stellarator-symmetric coil perturbations have been evaluated using the PIES code to calculate the self-consistent equilibrium and determine the island width as a function of perturbation amplitude up to 1 cm. The calculated island width is a factor of 3-5 smaller than the linearized model.

Project's recommended disposition: Closed, since the PDR design has been analyzed and found satisfactory.

Recommendation PHY-3. V3FIT Code and Associated Diagnostic Development

Responsibility: Physics Program, M. Zarnstorff; WBS 3, D. Johnson

CDR Panel Report: Continue V3FIT code development and associated necessary diagnostic development (a PVR recommendation).

Project Response: Agree. V3FIT is a long term project, for which the Theory program has responsibility. Magnetic diagnostics are the project's responsibility. The issue for the PDR is to estimate the number and type of sensors, reserve space in the model, and identify interfaces with the stellarator core.

Status: An initial physics assessment of the number and type of magnetic sensors required for equilibrium measurements was completed. The envisioned system includes in-vessel magnetic field probes, vessel-mounted saddle loops, flux loops co-wound with the magnets, plasma current Rogowski loops, and magnet current sensors. Interface requirements have been documented and the budget for addressing the system design issues (space requirements, mounting, cabling) is in the baseline, specifically in the Diagnostic (WBS 3) and Stellarator Integration (WBS 19) work packages. The baseline also includes the fabrication and installation of a subset of the sensors, namely those that are trapped between the vacuum vessel and modular coils and those co-wound with the coils. Since these cannot be retrofit after the device is built, they are included in the MIE scope (WBS 31).

Project's recommended disposition: Closed, since plans for diagnostic development are included in the project's baseline. Continue V3FIT development and application to NCSX as a program task outside of MIE scope, as funds permit.

Recommendation PHY-4. Additional PIES analyses

Responsibility: Physics Program, M. Zarnstorff

CDR Panel Report: Extend the use of the PIES code to additional flexibility studies.

Project Response / Status: PIES analyses of reference design-basis equilibria were carried out to validate the baseline modular coil design. More extensive study will be done as part of the research program for developing strategies and algorithms for magnetic surface quality control using the upgrade internal trim coils.

Project's recommended disposition: Closed, since the PDR design has been analyzed and found satisfactory. Continue PIES development and application to NCSX as a program task outside of MIE scope, as funds permit.

Recommendation ENG-1. Expedite Coil Properties and Cooling R&D Activities

Project Responsibility: WBS 14, B. Nelson, J. Chrzanowski.

CDR Panel Report: R&D efforts need to be pushed earlier and expediently accomplished. These include tests of the epoxy-potted flexible conductor with respect to mechanical and thermal properties for incorporation into stress, thermal analysis, and tests of the chill plate cooling method on the planar test coil to evaluate conduction as a function of required preloads and contact area, and obtain the necessary keystoning data for incorporation into the design of the winding forms.

Project Response / Status: Conductor properties and allowables tests have been completed at CTD and the University of Tennessee to support the preliminary design of the modular coils. The properties data, which indicate that thermal stresses should be reduced during a pulse, are being used in the mechanical and thermal analyses. A modified cooling configuration was developed, consisting of cooled chill plates external to the ground wrap. This design is incorporated in the demonstration ("racetrack") coil in order to evaluate its fabricability and cooling performance. Further development is included in the plans for the subscale prototype (the so-called "twisted racetrack") which will also be fabricated based on the chill plate concept. All these costs are included in the project baseline.

Fallbacks, if needed, include introducing chill plates between layers and switching to internally-cooled conductor. In that case, the cost of the attendant re-design, additional manufacturing development, and testing would be covered by contingency.

Project's recommended disposition: Closed, since the recommended work was started, and the remaining work and risk mitigation plans are covered within the project's budget.

Recommendation ENG-2. Expedite Winding and Epoxy Impregnation R&D Activities

Project Responsibility: WBS 14, J. Chrzanowski

CDR Panel Report: The NCSX team should start R&D on coil winding and potting techniques at the earliest possible time to develop expertise in the forming and required clamping of the conductor into twisted, non-planar forms, tooling required to set up the winding lines, and in the epoxy impregnation techniques required to ensure a good fill with the complex geometry.

Project Response / Status: Agreed. Work started early in FY-2003. The epoxy impregnation process was developed based on tests showing excellent wicking of epoxy into the flexible cable, filling all voids. The expected conductor cross section deformation ("keystoning") was quantified, based on measurements, as a function of bend radius and used to set allowances for keystoning in the winding. Future work, which includes fabrication and testing of subscale demonstration coils (both simple and twisted racetracks), is included the project's baseline.

Project's recommended disposition: Closed, since the recommended work was started, and the remaining work and risk mitigation plans are covered within the project's budget.

Recommendations ENG-3, ENG-5, CS-3, ASSY-1. Optimize Delivery-Assembly Sequence.

Project Responsibility: WBS 1, B. Nelson

CDR Panel Report (ENG-3): The NCSX team should examine ways to speed up production/delivery of the coil winding forms.
CDR Panel Report (ENG-5): Develop alternatives for manufacturing and assembly planning to accommodate the most rapid delivery schedule that can be achieved by the form vendors.
CDR Panel Report (CS-3): Implement measures by CD-2 to enable acceleration of the critical and near-critical path activities (primarily modular coil production and vacuum vessel production) to reduce schedule risk.
CDR Panel Report (ASSY-1): Consider potential alternative assembly plans to interface with vendor delivery and coil winding.

Project Response: Agreed. Expediting production of winding forms and putting more float into critical path has been a priority in planning and setting the baseline schedule. The project schedule and assembly sequence were developed with the aim of providing increased schedule flexibility.

Status: Measures taken:

- The modular coil R&D and production plans have been coordinated so that the first production coil will be of the same type as the prototype and use the same tooling. The work has been scheduled to eliminate a long delay between the prototype and production phases. These measures are expected to save time and improve efficiency. Planning the R&D (choice of prototype coil type) and coil winding/assembly activities to give the suppliers maximum freedom to manufacture the coils in whatever order is optimum.
- Adopted the scheme of assembling three-coil subassemblies over the vacuum vessel instead of one coil at a time.
- The schedule currently shows the coils being manufactured by shape, which is believed to be preferred for manufacture, but the three-coil assembly scheme could accommodate other sequences with no negative impact.
- The vacuum vessel ports will be fabricated in parallel with the shell.
- The manufacturing development contracts for the winding forms and vacuum vessel were placed. Cost and delivery schedule for the production components were a factor in supplier selection. Supplier cost and schedule input has been folded into the baseline.
- The project has developed a baseline plan that balances cost, schedule, and technical risk. The schedule has about 5.5 months of schedule contingency. Despite a 6-month delay in the project start, the projected First Plasma date has only shifted 3 months, partly because of project's successes in optimizing the schedule.

Project's recommended disposition: Closed, since the recommendation was heeded and cost and schedule implications are included in the baseline. The project will continue to look for ways to improve the schedule.

Recommendation ENG-4. Fabricate and test a demo coil

Project Responsibility: WBS 14, B. Nelson.

CDR Panel Report: A demo coil should be fabricated and operated at cryogenic temperatures early in the procurement process to provide input into unforeseen problems with the design and/or manufacturing. This coil needs to be highly instrumented with regard to stress and strain in critical areas, temperature measurement and subject to repeated thermal and mechanical cycling.

Project Response / Status: The project is proceeding along a path of addressing the issues in stages by fabricating a series of development articles with progressively increasing degrees of difficulty. Two subscale racetrack coils will be fabricated and tested. The first (the "simple racetrack") was built at PPPL and will be tested at ORNL prior to the PDR. The second (a "twisted racetrack" which is more prototypical of the tight compound bends in the actual coils) will be wound and tested at PPPL this winter. These activities will advance the development of coil fabrication methods and cooling schemes and will test important aspects of performance. Following these tests, the full-scale prototype coil, wound on a prototype winding form, will be tested as recommended. Finally, the first of each type of production coil will be tested individually at current and temperature. Some of the initial steps in this program have been completed and all of these plans are folded into the project baseline.

Project's recommended disposition: Closed, since the recommendation to test a full-scale demo coil was heeded in the development of the project baseline. Two subscale demo coils are also included in the budget. One is already wound and scheduled for testing prior to the PDR.

Recommendation ENG-5. See ENG-3.

Recommendation ENG-6. Carefully plan QA measures for manufacturing and assembly

Project Responsibility: WBS 82, W. Reiersen; WBS 83, J. Malsbury.

CDR Panel Report: QA measures must be planned very carefully in all steps of manufacturing and assembly.

Project Response / Plan: It is agreed that QA measures are critically important in the design, fabrication, and assembly of the stellarator core. Line management is responsible for assuring that adequate measures are taken to assure quality. QA professionals will be directly involved in the review of the design; design documentation; procurement documentation; manufacturing, inspection, and test plans; and installation and test procedures.

Status: Examples of formal QA measures taken during Preliminary Design: The NCSX QA Plan was issued in November, 2002. Formal Manufacturing, Inspection, and Test Plans and QA (MIT/QA) Plans have been developed for the manufacturing prototypes of the MCWF and VV. Supplier QA plans are requested as part of the procurement proposal packages and are weighed in the evaluation process. In updating its estimates for the winding and assembly operations, the budgets have been significantly increased, in part to ensure adequate oversight by design engineers and QA professionals, and adequate inspection and metrology. The Laboratory has planned increases in QA/QC staff to meet NCSX needs.

Project's recommended disposition: Closed, since the recommendation has been heeded in developing the project baseline and in planning Laboratory staff.

Recommendation AUX-1, CS-2. Legacy Equipment testing.

Project Responsibility: WBS 22, W. Blanchard; WBS 25, T. Stevenson; WBS 61, L. Dudek

CDR Panel Report (AUX-1): Responsible engineers should identify critical, one-of-a-kind components (particularly components that may not be repairable or replaceable) in legacy systems, and develop a test plan that checks these components before assembly and installation of the complete system.
CDR Panel Report (CS-2): Identify by CD-2 reused equipment that could have significant impact on cost and schedule if it is not functional when required by the project. This equipment should be tested as early as possible to identify cost and schedule impacts.

Project Response /Status:

Vacuum Pumping (WBS 22) The testing of the legacy turbo-molecular pumps (TMPs), power supplies, and backing pumps has been completed for assessing their use on NCSX. Three of the PBX Leybold 1500 TMPs were mounted on a test stand and run for a minimum of 4 hours. The pumps operated satisfactorily. The 4th PBX TMP is being used on MRX and is also operating satisfactorily. We plan on sending all 4 pumps out to be refurbished prior to their installation on NCSX. (Two are required to be installed and operational for First Plasma.) Therefore all TMPs for use on NCSX are available and the purchase of additional high vacuum pumps is not required.

One TMP converter (power supply) is in use with MRX and is satisfactory. Another three were used in the testing of the TMPs and were satisfactory. Therefore all converters needed for NCSX are available.

The four Sargent Welch 1398 mechanical backing pumps were tested at their present location in the PBX/PLT sub-basement. The pumps were cleaned up and the oil changed prior to running each pump for a minimum of 8 hours. All of the pumps operated satisfactorily with base pressures of 2.5 mTorr or less. Therefore all backing mechanical pumps for use on NCSX are available and the purchase of additional pumps is not required.

In summary, the condition of the equipment is good and any necessary repair or refurbishment costs necessary to prepare them for operation have been included in the baseline.

Neutral Beam Injection (WBS 25). The evaluation of the legacy NBI equipment was completed in FY-03. In the ESAT building, two NBI beam boxes were pumped down to 10-6 Torr vacuum. The beam boxes were leak checked and verified for their integrity. The boxes achieved and held good vacuum for these tests.

In the C site NBI switchyard, the AC Power group performed various maintenance and repair tasks on NBI high voltage switchgear and transformers. These components are ready for high voltage and system testing. Two complete power supply line ups (system number 502,504) have been checked out for service. The downstream Accel power supplies will be configured to mate to these two line ups.

In the C site MG area, the NBI Accel rectifiers have had deionized water circulated through the ignitrons without leaks. Cleaning of these high voltage systems has commenced in preparation for hipots and system testing.

In the NBI Modulator vault adjacent to the NCSX Test Cell, all of the Accel Modulator Power Supply high voltage switch tubes have been hipotted to determine tube vacuum integrity and high voltage insulator standoff. The two tubes deemed best per these tests are being installed in the 502 and 504 Modulator cabinets for testing. "B" system deionized water has been circulated to test the Modulator water system and repairs have been undertaken to the controls and plumbing. The Modulators are on track to support system hipots and testing.

In summary the condition of the equipment is good and any necessary repair or refurbishment costs necessary to prepare them for operation have been included in the baseline.

Water Systems (WBS 61). A water pump and some of its associated instrumentation that services the neutral beam lines was evaluated and found to be in need of replacement, the cost of which is included in the estimate.

Project's recommended disposition: Closed, since the recommended legacy equipment tests have been completed, and the cost implications factored into the project's baseline.

Recommendation AUX-2. ECH Upgrade.

Project Responsibility: Physics Program, M. Zarnstorff.

CDR Panel Report: The future upgrade for ECRH may be considered since most stellarators rely on this heating method.

Project Response / Status: The General Requirements Document was modified to require that provision be made to accommodate 3 MW of ECH as an upgrade.

Project's recommended disposition: Closed, since the recommendation was heeded in ensuring the design can accommodate ECH as an upgrade.

Recommendation AUX-3. Adequacy of TMP Pumping Speed.

Project Responsibility: WBS 22, W. Blanchard.

CDR Panel Report: The location of the turbo-molecular pumps may need to be reconsidered in order to increase the effective pumping speed.

Status: The pumping speed of the TMPs in their CDR location was analyzed and determined to be well in excess of the minimum requirements.

Project's recommended disposition: Closed. The design calculations were confirmed in response to the recommendation.

Recommendation I&C-1. Timing system clock rate

Project Responsibility: WBS 5, G. Oliaro.

CDR Panel Report: The timing system and the real time plasma control system should be as fast as possible (at the time of acquisition). The present specifications should be increased by a factor of ten in speed. A synchronized clock rate of 0.1 microseconds should be both possible and affordable. The real time control system will be asked to do complicated analyses and plasma reconstruction in order to maintain the desired plasma configuration.

Project Response: Agreed. Indeed this is what was presented in the CDR, though there may have been a miscommunication. As indicated in the CDR, the old TFTR clock time base of 1µs (1 MHz) was deemed too slow for NCSX. Several new technologies exist to decrease the time granularity to 0.1µs (10¨ MHz) and this is the target specification for NCSX design.

Project's recommended disposition: Closed. The design is responsive to the recommendation.

Recommendation DIAG-1. Commissioning and magnetic configuration measurements

Project Responsibility: WBS 3, D. Johnson.

CDR Panel Report: Review, as project matures, allocations of funding and effort between diagnostics needed for commissioning in order to ensure that key measurements of magnetic surfaces and configuration properties are carried out effectively.

Project Response / Status: The Diagnostics (WBS 3) cost and schedule was updated as part of the project re-baselining for the PDR. The requirements for magnetic diagnostics were augmented to include more ex-vessel sensors and flux loops co-wound with coils. Magnetic sensors that are trapped between the vacuum vessel and the coils and cannot be retrofit later are budgeted in the MIE project. A basic e-beam mapping system is included in the baseline. The vacuum vessel ports were modified to improve tangential viewing. A new commissioning plan was adopted, in which first plasma and e-beam mapping will be done with the cryostat partially uninstalled and the coils at room temperature to facilitate engineering measurements and access to critical components during commissioning. Within tight project budget constraints, priority was given to ensuring that the basic machine could fully accommodate physics diagnostics requirements and planning commissioning activities to support the validation of magnetic configuration properties. The costs, up to and including first plasma, are covered in the project's baseline; e-beam mapping will be part of the research program.

Project's recommended disposition: Closed. The recommendation was heeded in developing the baseline. Though the scope of diagnostics in the MIE project is limited to First Plasma and initial field line mapping requirements, no needed capabilities have been precluded.

Recommendation RESH-1. Rapidly Deployable e-Beam Diagnostic

Project Responsibility: WBS 3, D. Johnson.

CDR Panel Report: Keep deployable field mapping apparatus within the NCSX machine, so that measurement may be done, as needed, without having to open the machine to vacuum.

Project Response: This is potentially a useful capability, which must be weighed against its costs and risks. The project baseline includes a budget for basic e-beam apparatus that is probably insufficient to provide this capability, but sufficient for initial e-beam mapping studies in the first few months of operation to screen for large field error problems and support an assessment of the long-term requirements for e-beam mapping and field error correction in the NCSX program. The needed equipment capabilities will be re-assessed at that time.

Project's recommended disposition: Closed. Although the recommended capability is not within the baseline MIE scope, it is not precluded.

Recommendation PWR-1. Trim Coil Power Supplies

Project Responsibility: WBS 4, S. Ramakrishnan

CDR Panel Report: Install the 6 Robicon supplies for operation of the trim coils within the Project Scope, with a cost implication of ~ $0.5M. Mapping stellarator flux surfaces is traditionally one of the first studies undertaken after the main power, coil and vacuum systems have been commissioned. A follow on task is to eliminate or reduce the size of any significant islands that might appear as a result of field errors. In order to carry out this task efficiently, the external trim coils should be made available essentially from the beginning of the operating phase.

Project Response: The external trim coil power supplies will not be needed at the beginning of the flux surface mapping phase, since the first step will be to map the uncorrected magnetic surfaces from the main coils, operating at room temperature, to establish a baseline. Therefore the trim coil power supplies are not included in the baseline. As noted in the response to RESH-1, the initial flux surface mapping campaign will use basic apparatus, be of short duration, and be followed by an assessment of the long-term requirements for e-beam mapping and field error correction in the NCSX program. The needed equipment capabilities, including the scope of trim coil power supplies needed, will be re-assessed at that time.

Project's recommended disposition: Closed. The recommendation to include the trim coil power supplies in the MIE scope was rejected because they are not needed to begin field line mapping experiments.

Recommendation UTIL-1. Liquid nitrogen plant *vs.* once-through system

Project Responsibility: WBS 62, G. Gettelfinger.

CDR Panel Report: Develop a cost comparison for a nitrogen reliquification system and the proposed once-through system.

Project Response: An estimate was made for the break-even point of a cryogenic liquid nitrogen facility *versus* a once-through system. The break-even point was found to be 72,000 gallons, or ten LN2 truckloads, per *day*, based on feedback from suppliers. For requirements exceeding this amount, an on-site liquification plant is appropriate. However, NCSX requirements are at most 2 truckloads *per week*, well below the break-even point, so the once-through system is the appropriate choice

Project's recommended disposition: Closed. The recommended analysis was completed.

Recommendation UTIL-2. Coil cooldown from room temperature

Project Responsibility: WBS 62, G. Gettelfinger, WBS 1, B. Nelson.

CDR Panel Report: Perform analysis of transient cooldown from room temperature and thermal recovery after a shot to demonstrate single-phase flow in the parallel cryogenic cooling circuits. The concern is stable flow of liquid nitrogen and the design approach used for cooldown of parallel flow paths. Is there a requirement for a flow control valve on each parallel line?

Project Response/ Status:
According to experienced contacts in the aerospace industry, the circulation of single-phase liquid cryogens as a heat removal mechanism is a routine method for producing "slush hydrogen" and solid cryogens. A particular example of a liquid cooling circuit can be found in the staging facilities for the Upper Atmosphere Research Satellite (UARS) deployed from the space shuttle Discovery in 1991. The Cryogenic Limb Array Etalon Spectrometer (CLAES) experiment, on board UARS, has both solid carbon dioxide and solid neon heat sinks. These cooling reserves were fused with single-phase liquid nitrogen and liquid helium circuits, respectively.

Submersible cryogenic pumps and related equipment are available from several vendors with experience in the liquid tanker industries, both in the over-the-road and ocean-going types. We believe that easily obtainable evidence shows the LN2 cooling approach is a sound scheme.

The cooling details of the coils have evolved significantly since the CDR. However, the design that evolved still requires a number of parallel LN2 flow paths. The internally cooled TF and PF coils heat up by 5K or less in the reference scenarios. The modular coils are indirectly cooled. Although the conductor temperature might rise as high as 123K (from 85K) during a pulse, the temperature rise in the LN2 is small (less than 5K) owing to the substantial thermal resistance between the conductor and coolant and the short cooling path length. These small changes in LN2 temperature result in very small changes in density, of the order of 3% or less. Plans are to cool with LN2 well above the saturation pressure (at the maximum expected temperature) to avoid two-phase flow. The combination of cooling with LN2 well above the saturation pressure and having low temperature rises (5K or less) in any of the cooling circuits should be favorable for avoiding flow instabilities. It is anticipated that passive flow balancing elements (e.g., orifices) will suffice for achieving proper flow distribution in the system.

Cooldown from room temperature will involve circulating cold, gaseous nitrogen within the cryostat. Maintaining single-phase flow is not an issue in this approach. Additional analysis is required to confirm that the stellarator core can indeed be cooled down from room temperature to cryogenic temperature within the specified 96-hour period.

Now that the cooling details are maturing, analyses in conjunction with tests are underway. A "racetrack" shaped coil has been fabricated and testing has begun. The results of this test will be used to validate the cryogenic cooling/flow analyses performed on the racetrack coil as a prelude to follow-on analyses and additional thermo/hydraulic tests to assure that the NCSX coil cooling designs will be able to achieve the required flow balancing, initial cool-down from room temperature, and transient cooling between pulses.

Update Nov., 2003: Analysis indicates that cooldown from room temperature occurs in 24 hours using gas in the cryostat. Cooldown between shots has been demonstrated by analysis and by experimental results from the racetrack coil. The requirement for flow control valves will be based on additional racetrack coil tests and on additional analysis that has not been performed but which is included in the project baseline.

Project's recommended disposition: Closed. Analysis and test results have bracketed the issue and remaining analysis to resolve the issue is included in the project baseline.

Recommendation ASSY-1. See ENG-5.

Recommendation ASSY-2. Assembly and Associated Tooling

Project Responsibility: WBS 18, J. Chrzanowski and M. Cole

CDR Panel Report: Develop detailed assembly techniques and requirements and the necessary tooling as designs of the shell and vessel sections mature.

Project Response /Status: Field Period Assembly Plans and Machine Assembly Plans have been developed for the PDR.. Tooling requirements and special design features required in the modular coils or vacuum vessel to facilitate metrology, handling, and assembly have been identified, estimated, and included in the baseline.

Project's recommended disposition: Closed. The recommended analysis was completed and the cost and schedule implications are included in the project baseline.

Recommendation ASSY-3, MGMT-4. Integrated Testing and Commissioning Plan

Project Responsibility: WBS 85, C. Gentile.

CDR Panel Report (ASSY-3): Develop an integrated testing and commissioning plan
CDR Panel Report (MGMT-4): Develop a preliminary commissioning and test plan. This documentation should be prepared for CD-2.

Project Response /Status: Responsibilities have been assigned and a plan (the Test and Evaluation Plan) has been developed to the level needed to identify requirements and estimate costs and is documented for the PDR. It identifies the testing and commissioning tasks that need to be carried out to support CD-4. Details of the plan will be developed as needed to satisfy planning requirements and be ready for CD-4.

Project's recommended disposition: Closed. The requested plan has been documented for CD-2.

Recommendation MGMT-1. First Plasma Definition for CD-4.

Project Responsibility: WBS 81, H. Neilson

CDR Panel Report: Define an integrated end-of-project milestone reflecting the unique stellarator character of NCSX.

Project Response: The first plasma definition in the Project Execution Plan was modified to indicate that a significant fraction of the rotational transform will be generated by stellarator fields from the coils, and the 3D plasma geometry will be verified by visible imaging.

Project's recommended disposition: Closed. Integrated end-of-project metrics are documented in detail in the PEP.

Recommendation MGMT-2. Quantitative Project Completion (CD-4) metrics

Project Responsibility: WBS 81, H. Neilson

CDR Panel Report: Develop quantitative metrics defining Project Completion (CD-4) prior to CD-1.

Project Response: The end-of-project milestone definition in the Project Execution Plan was expanded to establish quantitative metrics for the coils, power supplies, vacuum vessel, vacuum pumping system, controls, and neutral beam system.

Project's recommended disposition Closed. Integrated end-of-project metrics are documented in detail in the PEP.

Recommendation MGMT-3. Finalize AEP and PEP.

Project Responsibility: WBS 81, H. Neilson

CDR Panel Report: Revise and finalize the AEP and Preliminary PEP in concert with the DOE Project and Program Managers as necessary to secure the approval of these documents by CD-1.

Project Response: Modifications suggested by the CDR panel and comments from DOE were incorporated into the Acquisition Execution Plan (AEP) and the Preliminary Project Execution Plan (PEP). These documents were approved in 2002.

Project's recommended disposition: Closed. The documents were approved.

Recommendation MGMT-4. See ASSY-3.

Recommendation MGMT-5. PPPL-ORNL Memorandum of Understanding.

Project Responsibility: WBS 81, H. Neilson and J. Lyon

CDR Panel Report: Incorporate the PPPL-ORNL MOU into the Preliminary PEP as an appendix.

Project Response: The PPPL-ORNL MoU documents understandings between the two institutions concerning their desired roles, responsibilities, and ratio of effort in various phases of the project. All matters that are relevant to how the project is to be managed are documented in the body of the PEP, which is more up-to-date and more detailed than the MoU, and is signed by both Laboratories and by DOE. The Project and DOE agreed not to include the MoU in the PEP.

Project's recommended disposition: Closed. The recommendation was rejected.

Recommendation MGMT-6. WBS 1 Management Responsibilities

Project Responsibility: WBS 82, W. Reiersen.

CDR Panel Report: Specify Level 3 management of WBS 1 (the Stellarator Core) by CD-1.

Project Response: The engineering organization for the preliminary design phase has been defined to a greater level of detail. As part of this, WBS managers for the stellarator core subsystems have been defined as recommended. The revised organization is documented in the Project Execution Plan.

Project's recommended disposition: Closed. The recommendation was heeded in developing the organization at a more detailed level following the CDR.

Recommendation ESH-1, CS-3. Expedite NEPA Process.

Project Responsibility: WBS 83, J. Levine.

CDR Panel Report (ESH-1): Consider ways to accelerate the EA process and complete it as expeditiously as possible.
CDR Panel Report (CS-3): Implement … recommendations of Section 4 that accelerate completion of the NEPA (EA) process.

Project Response / Status: By following a strategy which accelerated the process, the NCSX EA process was completed ahead of schedule with the approval of a Finding of No Significant Impact (FONSI) by the DOE Chicago Operations Office in October, 2002.

Project's recommended disposition: Closed. The EA process for CD-2 was completed expeditiously.

Recommendation CS-1. Preliminary Operating Cost Estimate.

Project Responsibility: WBS 81, H. Neilson

CDR Panel Report: Prepare a preliminary annual NCSX facility operating cost estimate, based on the envisioned research program, that includes costs for planned diagnostics and upgrades, by CD-2.

Project Response / Status: Facility operations cost estimates have been developed using NSTX as a model, corrected to account for differences and for efficiencies stemming from joint operation of the two facilities with some shared equipment. Research staffing and upgrade needs were also estimated. Upgrades envisioned for the first 4-5 years of NCSX operation are documented in the General Requirements Document (which requires that the facility be designed to accommodate them) and the Project Execution Plan. Their estimated cost is broadly consistent with the planned investment in equipment upgrades and the research program needs for those years. Upgrade plans and budgets for the first two years have been developed in more detail. The annual operating cost estimates for a typical year are documented in the Project Execution Plan.

Project's recommended disposition: Closed. An estimated operating cost is documented in the PEP.

Recommendation CS-2. See AUX-1.

Recommendation CS-3. See ENG-3, ENG-5, & ESH-1.

Project Responsibility: WBS 81, H. Neilson

ACTION-1. Reconcile Funding Profile with DOE Guidance.

CDR Panel Report: Resolve annual BA funding levels for FY 2004 and beyond with the OFES Program, and adjust project cost and schedule if warranted, prior to CD-1.

Project Response / Status: Revised annual funding guidance was provided by OFES at the Integrated Project Team meeting of June 4, 2002, as documented in the minutes. The profiles, TEC, and project completion were adjusted accordingly and documented in the Preliminary Project Execution Plan.

Project's recommended disposition: Closed. The reconciliation was completed prior to CD-1.